The Teaching Practices Project:

Research into teaching practices in Alberta schools that have a history of students exceeding expectations on Grade 9 provincial achievement tests in mathematics

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Research project commissioned
by Alberta Education

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EDUCATION

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TO: Superintendents of Schools
Junior and Senior High School Principals
Executive Directors, Regional Consortia

RE: THE TEACHING PRACTICES PROJECT

I am pleased to send you the report of the *Teaching Practices Project*. This research project was commissioned by Alberta Education to describe, analyze and interpret the teaching practices in schools whose students have a history of performing well on the grade 9 provincial achievement test in mathematics. The study was conducted by Professor Elaine Simmt and a research team from the University of Alberta.

One of the priorities for education in Alberta is to improve student achievement in mathematics, especially at the secondary level. A number of factors contribute to students' success in mathematics and other subjects. The teaching practices project addresses one of the most important aspects of any successful program: the role of the teacher. Teaching is a very complex process so there are no simple relationships between specific teaching practices and student achievement. As the researchers note, teaching also is a highly personal act: *"It is an act of the person and it is the process of human interaction involving particular individuals in particular contexts"*.

However, the researchers were able to identify and describe a number of features of successful teaching practices in the schools that they studied. By documenting teaching practices in Alberta schools, this report gives teachers and mathematics education leaders in this province an opportunity to read and work with case studies that may be relevant to their own circumstances.

We trust that this report will provide teachers and curriculum leaders with ideas for consideration to foster student success in mathematics. The report is being sent to both junior and senior high schools as student achievement in junior high mathematics, especially in grade 9, is a significant predictor of student success in senior high school mathematics. The report also may be useful in planning professional development opportunities for school and school system staff.

Sincerely,

Keith Wagner
Director
Curriculum Standards Branch

Enclosure

Printed on Recycled Paper

Long Abstract

The *Common Curriculum Framework for K - 12 Mathematics*, the achievement testing program, and the development of the Pure and Applied Mathematics programs for high school mathematics have been developed, at least in part, with the purpose of attaining high standards in mathematics education in the Province of Alberta. As Alberta Education continues to work towards improving mathematics education, there is ongoing reflection on the progress being made and action directed towards progress. As part of the goal of improving mathematics education in Alberta, the teaching practices research project was commissioned. Its purpose was to describe, analyze and interpret the teaching practices in schools whose students have a history of performing well on the grade 9 provincial achievement test (PAT) in mathematics. From the research, case studies were developed to describe some of the teaching of the 15 teachers who participated in this study.

Our search of the Alberta Education achievement test results data base identified forty-six schools across the province who met our criteria for strong school performance (see Appendix C). Twenty-two of those schools were in large cities. The remainder of the schools were from towns and rural areas. There were five private schools, including both religious and secular schools, and one charter school identified in the target population. The rest of the target population was made up of publicly funded public and separate schools. The target population was too large, given our resources to study in its entirety. Therefore, we selected a sample which included both urban and rural schools, schools from various regions in the province, large and small schools, and public (Catholic and secular) and private schools. Twenty-two schools were contacted and asked to participate in the project—ten rural schools, eleven city schools and one private school. Teachers in 13 schools agreed to participate in the study. In two of those schools we were able to observe two different teachers. This resulted in a total of 15 case studies.

Because teaching is complex and contextual, it is impossible to identify simple relationships between specific teaching practices and student achievement. However, we did identify and describe a number of features of the teaching practices of the teachers in the schools we studied. In the study, observations from a number of perspectives (parents, students, and administrators) were collected to try to take advantage of the multiple realities that are experienced in a mathematics class. Together with the observation of teachers teaching in their classrooms, the richness, or better yet the complexity, of teaching becomes more evident. From observing teachers in their classrooms we learned about some of the teaching practices in schools where the students are performing well on the PATs. These practices include:

- making mathematics real and relevant for students;
- making connections within mathematics and between mathematics and the physical world;
- caring about students' mathematics knowing;
- demanding instruction, both in terms of classroom behavior and the level of mathematical thinking;

- challenging content;
- highly interactive instruction;
- being well prepared for teaching;
- reflecting on one's own teaching practices and assessing one's own instruction;
- taking ownership of the curriculum.

The most important lesson we learned is that there is no recipe which lists a set of ingredients and methods for good teaching for all teachers. Teaching is a highly personal act. It is an act of the person and it is the process of human interaction involving particular individuals in particular contexts.

Teachers of the classes we observed are learners and doers of mathematics (and pedagogy) as much as they are teachers of mathematics. They lead by example and are good role models for the students in their classes. These teachers have an enthusiasm for mathematics and seem to get joy out of teaching the subject. The teachers in our study are self-confident both in their ability to do mathematics and in their teaching practices. For most of them, their teaching has been validated by strong student performance on past PATs, student and parent feedback, and by feedback from their colleagues and school administrators. But, these teachers also monitor their own work. We found that a number of the teachers in this study are highly reflective in terms of their own teaching practices.

The teachers we observed and interviewed indicated to us that they understand their primary task as teachers is to teach their students mathematics. To paraphrase one teacher, "my job is to teach them mathematics without hurting what is inside." The teachers were attentive to their students and it was evident that the teachers respected their students and demonstrated concern for them. These teachers realize that doing mathematics is part of and not separate from the daily lives and the growing up of their students.

In the schools we studied there is evidence that high expectations are placed on students both in terms of their behavior and in terms of their academic progress, and these expectations come from a multiplicity of sources. The students in the classes we observed participated very actively in the lessons that were taught. Each class, although quite distinct, had a climate which invited student participation. The student participation was most evident in terms of classroom discourse, engagement in tasks, and the offering of explanations.

The field researchers watched skilled practitioners encourage students' mathematical thinking and mathematical discourse. Rather than simply focusing on skill development or on problem solving or on concept development, many of the teachers in our study were adept at balancing these in their instruction. It was clear from the classroom observations that the teachers taught processes such as communication and making connections as they taught particular concepts and skills. The teachers in our study were very good at being able to adjust the difficulty of the tasks they assigned students, providing adequate scaffolding, and highlighting relevant cues to enable students to get into the activity and participate. Not all students were at the same level nor were they all able to accomplish every task the teacher offered; but with the

appropriate interaction with the teacher or other students, most students seemed to be able to participate in the mathematical thinking required for the lesson.

Explanations were clearly one of the striking features of the teachers' lessons in the classes we observed; however, we also noted the way in which teachers used various tools for enhancing discourse. For example, in most classes students used calculators to do computations for word and other kinds of problems. As well, all of the teachers encouraged students to use pictures or diagrams when solving problems. Teachers also modeled how tables and graphs could be used to help understand problem situations and to find solutions to various mathematical situations. In a few cases, the teacher used forms of dramatization and story telling to engage students' thinking.

Teaching is an intentional activity, a deliberate act. Enough cannot be said about the ways and the extent to which the teachers in this study are prepared and prepare to teach. This preparation came in many forms. All but two of the teachers in the study were either mathematics majors or minors and were considered by their schools to be mathematics specialists. All, but one teacher, have been teaching mathematics for a number of years. Many of the teachers in the study reported that they continue to attend inservice activities and read professional journals related to mathematics as part of their ongoing professional development. Further, the teachers knew the expectations of the curriculum not only for the grades that they taught but also for the grades that came before and after. The teachers' preparation was evident in their long range planning, day-to-day planning, and the ongoing reflection upon their own teaching practices. These teachers were constantly learning, changing, and developing their teaching practices in anticipation of teaching children mathematics and in the act of teaching mathematics.

As we look at these practices as a totality, the place and ownership of the curriculum begins to stand out. It stands out because most of the teachers in this study and many of their students behaved in ways that lead us to see them as taking ownership of the curriculum. The teachers and students talked about mathematics as though it were their own. Teachers selected examples and concepts to develop based on who their students are (their interests, abilities and prior experiences with mathematics), how the teacher sees and understands the mathematics and based on the teachers' understanding of the expected outcomes of the program of studies.

Teaching and learning go hand in hand. They are reflexive processes that are not reducible to their parts and cannot be understood in terms of cause and effect relationships. Rather, teaching and learning are best understood in context and in all of their complexity. In this project we designed a study that was attentive to the complex nature of teaching. The use of case study research to uncover and interpret the teaching practices in schools whose students have a history of performing well on the grade 9 PAT has been fruitful. We have learned much and what we have learned is documented in this report. The 15 cases provide accounts of the particulars of teaching and interpretations of our observations of those particulars. The cases are intended to be an interpretive site for educational leaders and teachers attempting to better understand mathematics teaching and learning.

The *Common Curriculum Framework for K - 12 Mathematics*, the achievement testing program, and the development of the Pure and Applied Mathematics programs for high school mathematics have been developed (at least in part) with the purpose of attaining high standards in mathematics education in the Province of Alberta. As Alberta Education continues to work towards improving mathematics education in the province, there is ongoing reflection of the progress being made and action of the progress being made. In November 1997, Hugh Sanders from the Curriculum Standards Branch of Alberta Education approached the Department of Secondary Education at the University of Alberta with a request for a research study that could be used to inform their mathematics improvement plan. In particular, Alberta Education wanted a study which would identify teaching practices that have a positive effect on mathematics achievement. In response to that request, a proposal for research to investigate the teaching practices in schools whose students performed well on the grade 9 achievement test was offered for Alberta Education's consideration and was subsequently accepted.

The proposed research incorporated a statistical component focused on identifying school and teaching (if available in the data source) variables related to strong student performance on mathematics achievement tests at the grade 9 level, as well as a qualitative study to investigate the practices and understandings of teachers who teach in schools where the students have a history of performing well on the grade 9 provincial achievement test in mathematics. Unfortunately the data source from Alberta Education did not have any information about teachers and/or teaching variables; thus the statistical component of the project was not possible. However, the primary interest in what successful teachers are doing in their classrooms was something to which case study research is well suited.

The timeline for the project was extremely tight and on many occasions I was concerned that I took on an impossible task. We were first approached to submit a proposal on November 21, 1997. I sent a preliminary proposal to the Curriculum Standards Branch of Alberta Education on November 26. On January 8, 1998 we entered into a contract to conduct the proposed research study. The required ethics review was immediately prepared and was approved on January 14.

Dr. Mark Gierl of The Centre for Research in Applied Measurement and Evaluation (CRAME) identified the schools which made up the target population on January 14 and the cooperative activities documentation was prepared and sent to the large school boards in Edmonton on that same day. Schools in other areas of the province were contacted and initial requests for school visits were made. (This part of the process took many hours on the telephone explaining the projects to superintendents, principals, and teachers.) Much to our dismay a number of schools that were approached to participate in the study declined. Their reasons varied. In the end, 13 schools out of 24 contacted agreed. Participating in the project are both rural and urban schools, schools from Northern, Central and Southern Alberta, large junior high schools, and not so large K - 12 schools, public schools and a private school.

While waiting for permission to get into schools, Mrs. Elizabeth Mowat and I reviewed literature related to teaching variables and student performance on standardized tests. A report of the review of the literature was submitted to Alberta Education on February 6, 1998.

Nine field researchers were hired to collect data and prepare the individual case studies: Florence Glanfield, Marie Hauk, Rick Johnson, Kathy McCabe, Joyce Mgombelo, Emile Pinco, Bryan Quinn, and Shannon Sookochoff. The first of the field researchers were out in the schools by the second week of February and the last finished collecting data from the field the third week of April. Each of the field workers not only collected data and analyzed it (in collaboration with myself and in some cases other field researchers) but prepared the written case reports that appear in this monograph.

Another component of the research study was based on the deliberations of a working group comprising a number of teachers who were observed for the study and the field researchers. On March 21, 1998 we met at the University of Alberta, discussed inservice education and developed principles for inservice education to bring forward to Alberta Education.

The Teaching Practices Project was a large endeavor because it was conducted in a short time frame, it involved sites around the province of Alberta, and it involved many levels of informants. The project was completed within three weeks of the scheduled deadline and on budget. The report itself is composed of two parts: the first is three chapters which describe the nature of the project, discuss principles for teacher inservice, and discuss the teaching practices documented in the cases. The second part of the report consists of the 15 cases studies—these are the highlight of this study. The literature review, selection criteria for the target population, and the research instruments can be found in the appendices.

The report of the Teaching Practices Project takes the form of an edited monograph with contributions from each of the field researchers. Although I have consulted on each of the cases, they were written by the field researchers. Thus each case is quite distinct. I believe the variation in the writing styles and the differences in content from case to case provide the reader of this report with far more to think about than might have been the case if each paper conformed to a prescription for style and content. However, I felt it was very important to draw the cases together in some way; so to do that I have prepared a commentary on the cases which describes what we learned as a collective. Case reports are written using the teacher as the unit of analysis; however, there were two schools in which two teachers participated in the study. They have been put together in a section and there are two rural school districts in which more than one school was studied—these also have been put together in a section. There is also a chapter that discusses the principles for inservice education that were developed by the participants of the working group. The literature review has been included as an appendix.

I must offer a most gracious thank you to the field researchers, F. Glanfield, K. McCabe, M.Hauk, R. Johnson, J. Mgombelo, E. Pinco, B. Quinn and S. Sookochoff for their willingness to persist especially when I returned their cases for yet another rewrite. Thank you also goes to Dr. Mark Gierl for his work to identify our target population, but

most of all for offering a fresh perspective whenever I consulted him. Thank you goes out to Elizabeth Mowat for her contribution to the review of the literature and Kelly Paul for gathering the papers and books for us to read. Thank you to Dr. Tom Kieren for supporting this project in a variety of ways. Finally, I must thank Dr. John Oster for editing and Saymah Chaudhry for making corrections to the final manuscript.

A very special thank you goes to the teachers who participated in this study. In this report, the teaching practices of some dedicated and wonderful teachers are offered for the mathematics education community to learn from. Our only regret is that because of ethical considerations (specifically in terms of confidentiality) we are not able to identify the teachers who participated in this study. All names of schools, principals and teachers have been changed.

There are many ways this document can be read and I believe many audiences for whom the report will be interesting. Each section can be read without reading the others. Thus, when you read this document you might very well choose to simply read the commentary for an overview of the teaching practices in schools whose students do well on the grade 9 provincial achievement test in mathematics. Or, you might simply read a single or several cases to learn about the teaching practices of a specific teacher or teachers. Others, those involved in teacher education for example, might be interested in the principles for inservice education. I encourage all readers to read at least a couple of the cases. It is in those papers that you will learn about the teaching practices that we observed in the schools whose students are performing well on the grade 9 provincial achievement test in mathematics.

Bruner (1986) describes two modes of thought: the paradigmatic and the narrative. This report engages the second mode through story telling. By telling stories of the teaching practices of teachers in schools where the students do well, there are many places where the stories of the readers will intersect with these and open up possibilities for reflecting on the teaching and learning of mathematics.

Elaine Simmt
Project Manager
Edmonton, May 1998

Part one: The Teaching Practices Project

One

An Introduction to the Teaching Practices Project

Elaine Simmt

Introduction

The purpose of this project is to inform teachers and mathematics education leaders regarding the teaching practices in those schools that have a history of strong student performance on Alberta's grade 9 provincial achievement test (PAT) in mathematics and to develop principles for inservice education. Given that there is a new mathematics curriculum in Alberta schools for which there is little available data from achievement testing, the research study component of this project should be considered as exploratory and further studies should be done based on the results of this study and the results of achievement testing over the next three years.

The project consisted of three parts: review of the literature of the teaching variables related to student achievement (Appendix A), case research involving teachers from schools whose students have a history of performing well on the grade 9 PAT (Part Two), and the articulation of principles to inform teacher inservice education (Appendix B). The research study was designed to collect information from classroom observations, interviews with teachers and administrators, and surveys from parents and children in order to identify, describe, and interpret the teaching practices in these Alberta schools. The second component of this research is to use the information from the classroom observations and interactions with teachers in the field to develop principles for inservice education which will be used to inform mathematics education leaders' and their work toward the goal of improving mathematics education for all Alberta students.

The research reported here involves the investigation of teaching in context and in all of its complexity. By documenting teaching practices in schools where the teachers are working with curriculum outcomes common to all grade 9s in the province, teachers and mathematics education leaders in Alberta will have the opportunity to read and work with case studies that are relevant to their own circumstances (at least in part). Further this research is valuable for teacher education in general. Case studies are one way in which preservice teachers can be introduced to issues related to mathematics teaching and learning. At the same time case studies can be used in inservice education. Practicing teachers are able to interpret cases having experienced for themselves teaching mathematics in secondary school classrooms. There is a potential for teachers pedagogical understanding to grow by reading case studies as part of their own reflective practice.

Limitations of the study

At the request of Alberta Education, schools were selected for this study on the basis of how well their students have performed on the grade 9 PAT in mathematics. (This is described in detail in Appendix C.) There are many other ways in which we could have defined good performance in mathematics or schools whose students are good

at mathematics. When speaking to school district officials and principals it was clear that some of them felt that the study suffered a significant limitation based on defining our target population and questioned why we would only consider teaching practices in the schools where the students were doing so well on the PAT. They pointed out that there were teachers in many other schools that had excellent teaching practices and great success with the students with which they were working. We do not claim that our target population consists of schools whose teachers all demonstrate exemplary teaching practices, nor do we claim that we have identified all the schools whose teachers demonstrate exemplary teaching practices. A second concern of many of the principals and teachers in the schools we spoke to, is that it is not just the teaching practices of the grade 9 teachers that should be considered when trying to understand the students' success. They were quick to point out the importance of the teachers who teach the children prior to grade nine. We agree with these educators, however, this was a delimitation of the study. Further, the teachers and school administrators also commented frequently on the important role the parents play and almost always credited the students, themselves, for being highly motivated and committed to learning. This is a study focused on teaching practices and teaching practices are contextual. We realize there are many complicit factors that we simply are not studying in any detail. Further research involving a set of longitudinal case studies would be a valuable way to learn more about the symmetrical relationship (Bauersfeld, 1989) between teaching and learning. To the extent that our work is case study research, we will however, attempt to describe the context the teacher is working within. The limitations of our study must be kept in mind when interpreting the case studies and discussions of those cases.

> Teacher and student(s) *constitute* the *reality* of the classroom interactively. This also makes clear, from theoretical explanation, why predictions in concrete classroom situations are so difficult and shaky. Through the analysis, reconstruction, and comparison of many cases, the patterns of interaction appear to function as a quite reliable hidden grammar of classroom activities." (Bauersfeld, 1988, p. 37)

Many educational researchers have struggled with these same concerns when trying to study teaching. Teaching is complex and contextual, thus it is impossible to identify simple relationships between specific teaching practices and student achievement. One of the problems with trying to identify the variables related to student performance is that performing well may in fact be something that is different for different school communities. That is, exceeding the standards set for a particular test may be strong performance for a school that attracts students who have a history of doing well in mathematics or who come from upper-middle class families; whereas meeting a standard may be good performance for a school whose students come from low income families or have a week performance history in mathematics. Further, we must not lose sight that we expect our students to learn more in our math classes than we can assess on paper-and-pencil tests.

Having said this, the literature we reviewed (Appendix A) does indicate that the content covered, cognitively demanding instruction, teacher clarity, and a business-like attitude are positively related to student achievement, as measured by paper-and-pencil

tests. But student characteristics, in particular prior achievement in mathematics, repeatedly have been found to be the factors most strongly correlated to student achievement.

Dimensions of the research and research questions

This research project was conceptualized by thinking about it in terms of a number of dimensions. Each of the dimensions contributes to the overall understanding of teaching practices that this research is intended to develop.

Dimension 1: Review the literature for factors correlated with student performance on standardized tests in mathematics.

What factors are correlated with student performance in mathematics?

What teaching practices are reported in the educational research literature to be correlated with student performance in mathematics?

Dimension 2: Analyze data from Grade 9 PAT provided by Alberta Education.

Which are the schools whose students perform well on the grade 9 achievement tests?

- Through an analysis of the data from Alberta Education (information accessible in the public domain), schools whose students perform well on the mathematics achievement tests at the grade 9 level were identified.

What are the variables related to high performance on the grade 9 PAT in mathematics?

- Using data from Alberta Education an analysis of school and teaching variables related to high performance on the grade 9 PAT in mathematics was intended. However, this data source did not have any relevant information for such an analysis: thus, the analysis was not conducted.

Dimension 3: Conduct a qualitative study of the teaching practices of teachers in schools where students have done well on the Grade 9 PAT.

What are the teaching practices of those teachers in schools where the students have a history of strong performances on the Grade 9 PAT?

- Identified teaching practices in the schools in which there is a history of strong performances by students on the Grade 9 PAT.
- Selected a sample of teachers from the target population to observe in action.
- Research assistants observed the practices of the teachers selected. They were observed while teaching mathematics in their usual classroom setting. This occurred over two to five class periods.

How do teachers whose students have strong performances on the Grade 9 PAT understand their own teaching practices?

- Interviewed the teachers who were observed teaching mathematics to learn what they understand to be the strengths and weaknesses of their own teaching

practices and to what they attribute the success of their students on achievement tests.

What views do parents express about their children's experiences in this teacher's mathematics class?

- Sent a questionnaire home to the parents of the children in this teacher's class to learn about the parents' views of their children's experiences in mathematics class and why the school may have achieved the results they have had.

What views do students express about their own mathematics education and experiences in this teacher's mathematics class?

- Collected this information by having the students in the teacher's class complete a questionnaire about their experiences in math class.

Dimension 4: Identify school and district based practices that are perceived to be related to strong student performance on the Grade 9 PAT.

What are the school based practices, if any, that may contribute to strong student performance on achievement tests?

What are the district based practices, if any, that may contribute to strong student performance on achievement tests?

- Interviewed the school principal to learn from his/her point of view, what if any school and/or district based policies are perceived to be implicated in strong student performance on mathematics achievement tests.
- Included questions in the teacher's interview with respect to school based practices that may be implicated in strong student performance on mathematics achievement tests.

Dimension 5: Develop principles for teacher inservice in conjunction with practicing teachers who participated in the Teaching Practices Project.

What principles might teacher inservice be based on in order to enhance teaching practices in mathematics classrooms?

- Conducted a daylong working session with the teachers involved in this study, the consultants, and the research team. The purpose of this working session was to identify the principles for teacher inservice which could be used to guide the development of inservice education for mathematics teachers.

Target population for cases

In this study, we were interested in observing the teaching practices in schools where the students perform well on the grade 9 PAT in mathematics. Our search of the Alberta Education achievement test results data base identified forty-six schools across the province who met our criteria for strong school performance (see Appendix C). Twenty-two of those schools were in large cities. The remainder of the schools were from towns and rural areas. There were five private schools, including both religious and secular schools and one charter school identified in the target population. The rest of the

target population was made up of publicly funded public and separate schools. The target population was too large, given our resources to study in its entirety. Therefore, we selected a sample which included both urban and rural schools, schools from various regions in the province, large and small schools, and public (Catholic and Non-Secular) and private schools.

Twenty-two schools were contacted and asked to participate in the project—10 rural schools, 11 city schools and 1 private school. Teachers in 13 schools agreed to participate in the study. In 2 of those schools we were able to observe 2 different teachers. This resulted in a total of 15 case studies. Teachers from 9 of the schools—8 city schools and 1 rural school declined to participate. The reasons given by teachers and administrators for declining to participate in the study varied: one teacher was reported as very shy; another teacher was on sick leave; one school was piloting a new computer-assisted learning program; another school just underwent a boundary change which has resulted in a very different school population; in a couple of cases the grade nine teacher was new to the school; one principal turned us down because there were already 6 research projects in the school; and, in two cases the administrators did not indicate why they chose not to participate.

Methods

This project was guided by principles for qualitative research (Stake, 1995) and the assumption that teaching, like learning, is a complex phenomenon (Stewart and Cohen, 1997; Kieren, Davis and Sumara, 1996) that resists reduction and simple explanations. The primary intention of the researchers was to carefully observe the actions and interactions in the teachers' mathematics classes in order to construct an image of the teaching practices in the schools we were studying; then using teacher interviews, refine the understanding to take into account how the teacher understood his or her own practices. Principal interviews and parent and student responses to survey items were then to be used to triangulate the data collected in the classrooms and from the teacher. In this case study research, the researcher is the primary "research instrument;" thus I believe it is important to acknowledge that the members of our research team began with personal assumptions of what defined good teaching practices. Part of the research process involved considering this very issue.

Prior to the field work, the researchers met to discuss the ways in which data would be collected in the field. It was clear after just one meeting, that we all had very strong (and not necessarily coincident) views on what constitutes good teaching practices. We came face to face with these views after watching a 20-minute video of a student teacher teaching a grade 10 math class. This video stimulated discussions around the notions of *observing for the teacher's teaching practices* and *observing for something in particular in the teacher's instructional practices*. Admitting to our biases, we discussed observational strategies for documenting what was happening in the mathematics class without anticipating and pre-judging the teacher's behavior. In the end, we used *Case Study Research* (1995) by Robert Stake and the NCTM's *Professional Standards* as sources for developing our observational strategies. We agreed to make note of: the community, school and classroom environment; the actions and interactions of the

teacher; the discourse in the classroom; the mathematical tasks the teacher used in instruction and assigned to students; and the tools used to facilitate mathematics learning. We met as a team four times prior to the commencement of the field work and three more times (as a team) during the field work (not all researchers were at the same point in their field work at the time of these meetings).

Data Collection

For each of the schools in our study we collected data in a variety of forms. For example, in a number of schools we did not have permission from the parents of all of the students to videotape the lessons we observed, thus we chose not to bring the camera into the classroom. In all but three cases we did, however, audiotape the lessons. We felt this was far less intrusive and were assured by the teachers that this would not be a concern since it was very unlikely that any student could be identified simply through verbal utterances. Other than the exception noted above, data were collected in the following forms for each teacher observed.

1) Classroom Observations
   - The teacher was observed teaching grade 9 mathematics over two to five class periods.
   - The researchers took field notes and made audio and video recordings (where possible).
   - A particular observation instrument was not used; instead, researchers were instructed to record in as much detail as possible events, actions and interactions that they observed.
2) Teacher Interview
   - An interview with the teacher was conducted using the interview protocol in Appendix D. The purpose of this interview was to solicit the teacher's perspective of the teaching and learning in this school. The interview was audio recorded.
3) Principal Interview
   - The principal was interviewed (Appendix E) either by phone or in person to solicit his or her views on the teaching and learning in the school. This interview was (in almost all cases) audiotaped.
4) Parent Survey
   - A survey (Appendix F) was sent home to the parents of the students in the classes that were observed to learn about the parents' perspectives of the teaching and learning in their child's school and classroom. The response rate for the schools varied from about 25% to 100%.
5) Student Survey
   - Students completed a questionnaire (Appendix G) that asked them about some of their experiences and perspectives related to mathematics teaching and learning.

In only a few instances did the students not complete the questionnaire; thus the response rate was between 95% and 100%.

Research artifacts include:

- field notes from the classroom observations
- audiotapes and transcriptions of those tapes taken during classroom observations
- videotapes taken during the classroom observations
- audiotapes and transcriptions from teacher interview
- notes and/or audiotapes and transcriptions from principal interview
- parent questionnaires
- student questionnaires

Data Organization

The various artifacts were handled and organized in ways suitable for the data type. In particular, field notes, audiotapes and videotapes were analyzed using qualitative techniques to develop an understanding of the teacher's instructional practices. Initially, the nature of the teacher and student discourse, the tasks used within the instruction, the tools used for enhancing discourse, the structure of the lesson and the use of routines were used as themes to organize the data. Teacher interviews were transcribed and coded, and the themes initially used were modified and new ones developed by the researcher and project manager. Principal interviews were reviewed with the intent of both expanding and triangulating the researcher's interpretation of the data collected from the classroom observations and the teacher interview. Information from the parent and student surveys were reviewed and used to further triangulate the researcher's observational data.

Developing the Cases

Each field researcher has prepared his or her own case or cases. The cases reflect the differences in the researchers' interests and interpretations as well as the differences in the teachers and schools. As project manager, I felt it was important for the writing to reflect the differences; thus I encouraged each researcher to write up the case in the way that he or she believed was appropriate. For this reason, there are significant differences in the styles of the writing and the forms used to report the cases. However, in each of the cases we read something about the context, the teaching practices employed by the teacher, the views of the teacher, illustrations from the teacher's classes, student and parent perspectives of the mathematics teaching and learning in the school, and administrator comments about the mathematics teaching and program in the school.

Working group

The third component of this study was a working group made up of teachers and researchers who had been involved in the classroom observations. The group met at the University of Alberta for one day and discussed various issues related to teaching mathematics but focused in particular on teacher inservice—the need for and the qualities of inservice activities. In particular the working group discussed the terms professional development and teacher inservice and came up with a distinction between the two that allowed the group to operationalize the notion of teacher inservice. The working group had an opportunity to comment on the value of using cases in the education of inservice and preservice teachers and advise the case researchers on what features of the case reports were valuable. On the basis of the day's discussions the working group then began to develop a set of principles to guide inservice education (Appendix B).

The research team

The various components of the research were facilitated by different members of the research team. All components were supervised and coordinated by myself, project manager and principal researcher. Dr. Mark Gierl of the Centre for Research in Applied Measurement and Evaluation at the University of Alberta identified the target population and consulted on the sample selection which was made by myself. Elizabeth Mowat, a high school mathematics teacher, and I reviewed the literature and prepared the report of our review. The case researchers included teachers from the Edmonton area, graduate students in the Department of Secondary Education at the University of Alberta, a Field Services Associate from the University of Alberta and mathematics education consultants. In alphabetical order, the case researchers were Florence Glanfield, Marie Hauk, Rick Johnson, Kathy McCabe, Joyce Mgombelo, Emile Pinco, Bryan Quinn, Elaine Simmt, and Shannon Sookochoff.

Overview of the teaching practices project report

Teaching and learning go hand in hand. They are reflexive processes that are not reducible to their parts and cannot be understood in terms of cause and effect relationships. Rather, teaching and learning are best understood in context and in all of their complexity. For this project we designed a study that was attentive to the complex nature of teaching. The use of case study research to uncover and interpret the teaching practices in schools whose students have a history of performing well on the grade 9 PAT has been fruitful. We have learned much and what we have learned is documented in this report. The 15 cases provide accounts of the particulars of teaching and interpretations of our observations of those particulars. The cases are intended to be an interpretive site for educational leaders and teachers attempting to better understand mathematics teaching and learning. Heinz von Forester (1981) claims the environment contains no information, it only contains energy rich matter and learning is selecting from that energy rich matter and integrating it into one's own structure. It is our hope that this report is energy rich matter from which the mathematics education community might select and learn.

Two

Learning from Teachers

Elaine Simmt

As I read and try to draw together remarks on the many things learned from this research, I am struck by Maturana's (1987) comment, "Everything is said by an observer." Reflecting on our observations from the classes we visited, we could not help but try to deduce why this or that particular school has the success it does on the Provincial Achievement Test (PAT) in mathematics. Mr. Grant at Chestnut Lane School commented, "I don't know what we do different here. We just do what other teachers do." Another teacher, Mr. Mullen observed, "The parents in this community are very supportive." Mrs. Dawson, a teacher in an urban school, said, "We attract some very, very top-notch students here." One of the students from St. Al's, a larger rural school, commented, "The teacher helps us understand. She never gives up." A parent from Alan Lane School remarked, "She [the teacher] provides an environment for learning, facilitates good learning and helps when asked."

These observations are from observers each commenting from a unique perspective and each pointing out the significance of a particular person, event, or way of interacting that he or she suspects may contribute to the students' success in mathematics. The difficulty with any research study or report such as this is that in selecting one observation or another as significant, it privileges either deliberately or unintentionally one perspective over another. Maturana (1987) reminds us that as observers we have no privileged perspective. There is no objective position from which to observe. There is no perspective from which we can view reality independent of ourselves, and our perceptive capabilities. When we do a study like this then, it is filled with observations that are made by individuals. The individual makes distinctions and can only offer what he or she observes.

In all of our comments as researchers, we must be reminded that the world is as it is and at the same time is only as we make it. In most of the cases in this study this paradox was clearly evident; teachers and students interacted together constrained by their personal knowing, and restrained by features of the environment to create the "mathematics class." The mathematics class is a phenomenon that emerged out of the interactions of teachers and students and the environment; their world was as it was, but at the same time it was what their joint action and non-action made it.

Whether in a large group discussion in which the teacher mediated the development of mathematical ideas, objects and concepts, or in a class in which students interacted with each other in small group settings and the teacher slipped in and out of their activity it was clear that the reality of that activity was a joint construction. Bauersfeld (1988) comments, "Both teachers and students contribute to the classroom processes. It is a jointly emerging "reality" rather than a systematic proceeding produced or cased by independent subjects' actions. . . . Teachers and students jointly constitute the reality of the classroom" (pp. 29–30).

I have placed this claim of the emergent mathematics classroom and constructed reality up front in this discussion as a reminder that the cases are particular and unique. Their value to us as educators is in their particularity, not in any generalizations that might be made from them.

In this study, observations from a number of perspectives were collected to try to take advantage of the multiple realities that are experienced in a mathematics class. Together with the observation of teachers teaching in their classrooms, the richness, or better yet the complexity, of their teaching becomes more evident. From observing teachers in their classrooms we learned much: the instruction was highly interactive; it was demanding both in terms of classroom behavior and the level of mathematics and mathematical thinking that was expected; teachers and students made connections within mathematics and between mathematics and the physical word; and teachers felt that they had a lot of support from outside of their classrooms. Clearly the most important lesson we learned, or at least had validated, is that there is no recipe which lists a set of ingredients and methods for good teaching for all teachers. Teaching is a highly personal act. It is an act of the person and it is an act that takes on meaning in relationships with particular learners.

In this chapter, I will discuss the themes and issues that arise from a reading of the cases. The chapter is organized by theme and draws illustrations and examples from the cases that follow in Part II. This is an odd way to organize the reading and in many ways misses the point of case study research in education; i.e., to offer thick and rich description of (in this study) the teaching practices of specific teachers. However, I do think it is useful to draw together themes that may help focus our investigation into teaching practices. If a reader prefers, he or she may choose to read the case studies before reading this general discussion of the study.

Making mathematics real and relevant

Teachers in the classes we observed are learners and doers of mathematics (and pedagogy) as much as they are teachers of mathematics. They lead by example and are good role models for the students in their classes. These teachers have an enthusiasm for mathematics and seem to get joy out of teaching mathematics. When doing mathematics with their students, many of the teachers and students, though not all, treated the mathematics like it belongs to them. It was their thinking, their possession. Only a few of the teachers used the indefinite pronoun "they" when talking about textbook or exam questions and/or answers. In my personal experience, I have often heard preservice and inservice mathematics teachers make comments like "they get this answer" or "they do it this way." Many of the teachers and students we observed simply did not refer to the mathematics that was taught and learnt in their classrooms in this disembodied way.

One interpretation of this observation is that the teachers and students who participated in our study saw the authority for mathematics in the mathematics itself (as was made evident by the ways in which most teachers explained answers and problems); but, it is also possible that the teachers and students saw mathematics as something that they themselves create by doing. One boy at Gilhooly School exclaimed, after he and his classmates worked up to a general form for a geometry situation, "[The other class] got this too?" In observing the action and this boy's remark, the case researcher felt that the boy sensed the personal creative aspect of such symbolic work; thus, he was surprised that others had arrived at the same mathematical expression. In that remark, we see the student's sense of, and surprise at, the coemergent nature of mathematics—it is at once a product of personal thinking and a social and cultural phenomenon. Such a realization might be a hallmark of a good mathematics classroom. This reflection by the case worker is only speculative, but if the boy experienced something like this—even if the

experience was fleeting—then the mathematics that he is learning in Mr. Wilchuk's class is something that belongs to the teacher and students, not just people who write textbooks or construct tests.

There are other ways that teachers made the mathematics something that the class shared, or individuals possessed, rather than simply something from outside themselves that they were to learn. Mrs. Hutniak at St. Al's is an example of a teacher who personalizes the mathematics by creating problems that have relevance to students in the class. Knowing many people live on farms, Mrs. Hutniak frequently uses illustrations from farming. Another example, is Miss McInnis. She expressed satisfaction with the new textbook she is using in her class commenting in particular on the illustrations, activities and exercises that demonstrate how mathematics is applied in "real world" contexts.

Teaching as caring

> The child wants to attain competence in his own world of experience. He needs the cooperative guidance of a fully caring adult to accomplish this. The one-caring [sic] as teacher, then, has two major tasks: to stretch the student's world by presenting in effect a selection of that world with which she is in contact, and to work cooperatively with the student in his struggle toward competence in the world. (Noddings, 1984, p. 178)

The teachers in this study understand their primary task as teachers is to teach their students mathematics. To paraphrase one teacher, "my job is to teach them mathematics without hurting what is inside." The teachers were attentive to their students and it was evident that the teachers respected the students and demonstrated concern for them. All of the researchers reported overhearing teachers talking to students and interacting with them on a personal as well as academic basis. These teachers realize that doing mathematics is part of and not separate from the daily lives and the growing up of their students.

The teachers were concerned with making a connection with their students. This concern was manifested in a variety of ways. For many of the teachers in the study, this meant talking to students about extracurricular activities in which the students participate. For Mrs. Hutniak and Ms. McInnis this meant visiting a local hockey rink on the weekend to watch students play. For Mr. Chieng and Mrs. Dawson this means goofy jokes and silly stories to accompany mathematics problems and explanations. For Mr. Hilyar, this means giving students class time to complete assignments because many of his students are kept quite busy after school on their family farms. For other teachers, their concern for students was manifested in the choices they made when selecting problems for the students to work on. For example, some teachers thought it was important to select what they referred to as "real" world problems—problems they felt were important for their students to know for their lives outside of school. Yet other teachers' concern for their students' lives was reflected in the demands they placed on the students to perform. The teachers in this study believe it is important for their students to do well in school in general but in mathematics in particular. Having said that, what counts as doing well was different from teacher to teacher and from student to student.

The teachers in this study were very attentive and aware of students' needs as they were related to learning mathematics. Mr. Chieng and Mrs. Dawson both teach strong academic students in special programs. Each of these teachers commented that they thought streaming

students was useful because then the teacher could teach to the appropriate level. On the other hand, Mrs. Hutniak and the other rural teachers do not seem as concerned about the diversity of their classrooms. Mrs. Hutniak commented that the only way the behaviour modification kids are going to learn math is to be in her classroom with the other students. Although the teachers' opinions differ as to what situation they think is best for their students, they share the objective of creating the best possible situation for their students.

> "The teacher receives and accepts the student's feeling toward the subject matter; she looks at it and listens to it through his eyes and ears. How else can she interpret the subject matter for him? As she exercises this inclusion, she accepts *his* motives, reaches toward what he intends, so long as these motives and intention do not force an abandonment of her own ethic." Noddings, 1984, p. 177

It is remarkable the extent to which some of these teachers went out of their way to teach each and every one of the students in their class. Most parents and students commented on the availability of most of the teachers to help students outside of class time. It was not unusual for the teachers in our study to give up a lunch break to help a student. Mr. Smith, who teaches in a school in a small community, commented that students were expected to call him at home in the evening if they were having difficulties. Another teacher included 6 students in her regular mathematics class even though they were in modified classes for all of their other course work. In all of our interactions with these teachers we never heard any of them speak negatively towards teaching mathematics nor did we ever hear them speak negatively or condescending towards their students. It is true that a couple of the teachers told researchers that they "did not expect the same results on the PAT this year," with their current group of students. These comments appeared to refer to the situations the teachers found themselves in and to indicate that the situation required different teaching strategies and expectations than had been used in the prior year. Nel Noddings (1984) remarks, "The special gift of the teacher, then, is to receive the student, to look at the subject matter with him." (p. 177). That is, the teachers note differences in students and groups of students and this makes a difference in their teaching practices.

Demanding instruction

> "The teacher works with the student. He becomes her apprentice and gradually assumes greater responsibility in the tasks they undertake." (Noddings, 1984, pp. 177–178)

This section could easily be one of the lengthiest in this chapter. If there is one single element that was common to all of the schools that we visited, it is something that I labeled as demanding instruction (see also Appendix A, literature review). Demanding instruction looks different in different classes, but it encompasses general themes of high expectations and challenging mathematics content.

High expectations

In the schools we studied there was evidence of high expectations placed on students both in terms of their behaviour and in terms of their academic progress; and those high expectations came from many sources.

Well behaved and highly motivated students

One of the first and long lasting impressions that we made from our visits is how well behaved the students were. The cases reflect how, for the most part, the students in the classes we observed came to class with their homework done, materials in place and prepared to participate in the class. They took notes, responded to questions, asked questions of the teacher, and worked independently on assigned tasks. This is not to say that all of the students had their hands up all the time, nor did all of the students in these classes do all of their homework all of the time and there were students whom the teachers had to ask to be quiet or get to work. However, the researchers, who themselves have been in many junior high school mathematics classes including ones of their own, were impressed by the attentiveness with which the students engaged in mathematics lessons.

The teachers in our study managed their classrooms very well; evidently, routines were in place for the movement of students in the classroom, the collection of materials, the assigning of homework, and the conversation etiquette in the classroom (see Leinhardt, 1988). The students appeared to know what was expected of them at various points in the lessons, they worked independently on exercises and when appropriate would follow along with the teacher—they knew how to participate in the particular mathematics class they were in. This did not mean that all of the classes had the same routines and patterns of teacher and student behaviour, nor does it mean that day after day the students follow the exact same lesson pattern. But, it is the case that the students knew the patterns of their particular classes and the classes ran very smoothly. Researchers commented that there was very little "down" time in the classes observed—most of the students were on task most of the time.

Of particular note was how students persisted with tasks over the entire period of instruction. In Mrs. Hutniak's class, it was quite remarkable how in the middle of a large group discussion she could turn her attention to a single student for 30 seconds or maybe a minute and the other students in the class would wait patiently. In Mr. Hilyar's class his students are accustomed to his having to leave the room to deal with administrative problems. He trusts them to work on their own and behave appropriately. In Mr. Albert's academic challenge class the students pick up math contest problems after they finish their daily work without being instructed to do so.

Demanding conversation

When differences in teaching practices out among the teachers in the study are easy to spot, it may lead one to believe that any particular teacher does not fit "the pattern" the researcher has noted—in this case the theme of demanding instruction. For example, Miss McInnis's classes were the only ones in which the students sat together at tables instead of at desks in rows. Her students were considerably more talkative than students in the other teachers' classes we observed. At one level this is a distinctive difference; however, the case researcher speculated that by the desk arrangement and the style of instruction the teacher may in fact be "demanding" conversation in her classroom. Thus this teacher, too, was demanding of her students, but her demands were different. Believing that students learn by talking and through using language, she set up a classroom which facilitated such activity. Sometimes the students' conversations included little mathematics, but at other times they were saturated with mathematics. In Ms. McInnis' class there was an interesting possibility ever present for

mathematics to permeate social conversations and social conversations to permeate mathematical ones.

Taking notes

A few of the teachers in this study, Mrs. Dawson, Mr. Wilchuk and Mrs. Hutniak, had very stringent criteria for note taking in their mathematics class. These teachers not only gave instruction on how notes should be taken, but also collected the student notebooks and marked them as part of the students' term work. The notes consisted of outcome statements, examples, explanations, diagrams, terminology, as well as, student exercises. The diversity we found is exemplified in the case of Mrs. Dawson and her colleague Mr. Albert. Even though they teach in the same school they do not share Mrs. Dawson's expectations for her students' rigor in note taking.

Challenging mathematics content

Teaching beyond the grade nine curriculum

One of the most surprising findings, from my perspective, is the number of schools in our study that shared an unexpected commonality; that is, the students were taught content beyond the grade nine curriculum. In the urban schools selected for our sample, it turned out that all of these schools had enrichment programs of one sort or another. Two of the schools offered an advanced placement course in which the students finishing grade nine would get credit for Math 10.[1] This was not the situation in the rural schools. None of the rural schools in our study had enrichment programs. We found this interesting and speculated about the differences between rural and urban schools. One of our conjectures is based on knowing that in many rural schools the math teacher teaches many levels of mathematics and thus is very familiar with the sequencing and scope of the mathematics curriculum. Further, in the case of rural teachers, they almost always see the students year after year. We speculated that if a teacher knows she will be teaching the same students the next year this teacher is likely to supplement the curriculum with content from the next year if only to foreshadow coming mathematics. Thus one of the commonalties among teachers in this study appears be that they are familiar with the Math 10 program and many of them supplemented, in one way or another, the grade nine content with more advanced mathematics.

Language and mathematics

The use of mathematical terms, expressions, and conventions was common in the classes we observed. Many of the students in these classes used such language with apparent ease. At the same time teachers in these classes seemed to be very attentive to language and the ways in which students would explain their thinking. This was more apparent in some of the classes we observed than in others. In all of the classes the teachers encouraged the accurate use of mathematical terms and expressions. Ms. Wright at Rock Mountain School talked about how she purposely is very repetitive in her math class. She believes this is how a person learns language thus this is an appropriate way to learn mathematics. Students in Mr. Chieng's classes

[1] We contacted 18 of the urban public schools on our target population and 15 schools had some form of academic enrichment program.

used mathematical terms in unusual ways. For example, they spoke of reciprocating a term and square-rooting a number. The teacher at St. Al's emphasized talking about mathematics and using language to make sense of mathematics. For example, she assigned the chapter in the textbook to be read prior to the beginning of a new unit. Then, at the beginning of the lessons taught early in the unit she would encourage the students to talk about what they read. New words were introduced slowly and meaning was developed through use and through manipulating the words in familiar contexts.

Tough questions

In the math classes we observed, students worked on tough questions. In addition to practice and skill development, we noted that the teachers frequently assigned the difficult questions from the textbook or from other materials. For example, in geometry, students found the area and perimeter of irregular shapes; in solving equations the students solved rate problems; in statistics the students were doing critical thinking. Furthermore, the teachers did not shy away from word and application problems. On the contrary, such problems were used both as illustrations in class and assigned for seat-work. It was also common for teachers to discuss changes to a problem that would make it more difficult and to talk about how hard problems could be considered from a number of angles.

It is interesting to note, as well, that the teachers did not express concerns that the new curriculum was overly demanding or time consuming. Rather, a number of the teachers' comments were more focused on the strengths of the new curriculum. One teacher did express a concern that the textbook he was using placed a heavy demand on the students reading ability, but another teacher saw this as a positive feature of the new book. She commented that this simply meant her students needed to read the material prior to the unit and then again as the unit was taught.

Math contests

Some of the teachers mentioned that students in their school prepare for and participate in the national mathematics contests. The academic challenge students at Alan Lane School spend one day a week working on math contest problems. These same students were seen to pick up math contest problems when they had finished their daily assignments. In contrast, the teacher at Apple Grove commented that his students have not worked on challenge problems as much this year as they have in the past because of the time needed for the new curriculum.

Interactive teaching

The students in the classes we observed participated very actively in the lessons that were taught. Each class, although quite distinct had a climate which invited student participation. The student participation was most evident in terms of classroom discourse, engagement in tasks and the offering of explanations and was readily observable in the cases of Mr. Wilchuk, Mrs. Hutniak, and Mrs. Weslosky.

One of the features of the classes we observed was the back and forth offering by teacher and students alike of ideas, words, comments and questions from which the mathematics of the class emerged. In all of the cases there are pieces from the transcripts that demonstrate the tone

of the classroom discourse. In only one or two of the classes were the student contributions to the large group discussion single word responses to textbook exercises or questions for clarification. In contrast, Mrs. Hutniak's was observed to spend 27 minutes working on a single word problem with her students. She orchestrated a group response to the problem filled with details of working on individual parts of it. In her class, students contributed as much as they could and then she would ask another student to join in and carry the process on. In most cases the researchers felt as though the teachers were carefully listening to each student's response, attending to far more than the answer to some question. They were instead attending to the student's understanding, the student's emotions that were being triggered and to the mathematics that was emerging. Nel Noddings points to the significance of such interaction.

> "When a teacher asks a question in class and a student responds, she receives not just the "response" but the student. What he says matters, whether it is right or wrong, and she probes gently for clarification, interpretation, contribution. She is not seeking the answer but the involvement of the cared-for." (Noddings, 1984, p. 176)

We, as researchers, watched skilled practitioners encourage mathematical thinking and discourse about mathematics. Rather than simply focusing on skill development or on problem solving or on concept development, many of the teachers in our study were adept at balancing these in their instruction. It was clear from the classroom observations that the teachers taught processes such as communication and making connections as they taught particular concepts and skills. Nickson (1988) claims that teaching processes "suggests links with activity and helps to present mathematics as an area of the curriculum in which students are actively engaged in doing mathematics as opposed to passively receiving something that is labeled "mathematics" (p. 249). The activity looked quite different from class to class, but the students in the classes were encouraged through the choices the teacher made for instruction to be active learners rather than passive learners. Classroom discourse was facilitated through the teacher's choice of tasks, questions, and requests for explanations.

The diversity in practice showed up in the interaction and the class discourse patterns. In some classes teachers did most of the explaining, in other classes the students did most of the explaining. I am struck by how the discourse involved explaining not simply telling. Leinhardt (1988) tells us, "The heart of any teaching episode is the explanation of an idea or phenomenon.... Regardless of which type of teaching one is describing, explanations given or the construction of an explanation are fundamental to the learning process" (pp. 56–57). Members of the classroom community were able and in many cases encouraged to offer their explaining to others. There was an expectation in a number of the classes that the explanations be for all members of the class not only a few. Clearly, explanation was a key feature in the teaching we observed.

The teachers in our study were also very good at being able to adjust the difficulty of the tasks they assigned students, providing adequate scaffolding to enable students to get into the activity and participate, and highlighting relevant cues for the students. Not all students were at the same level nor were they all able to work on every task the teacher offered; but with the appropriate interaction with the teacher or other students most students seemed to be able to participate in the mathematical thinking required for the lesson. There is an important distinction to note here. The teachers were not doing the thinking for the students; rather they participated in mathematical thinking with the child or in some cases for themselves in the student's

presence. Teachers in this study were good at being able to find entry points for each student into the mathematics being taught. One of the most common comments we heard from parents about the rural teachers in the study was that they explain until everyone understands. Although this comment suggests that it is the teacher who explains until everyone understands, a number of the researchers noted how the teacher and the students offered multiple explanations. The teaching in the classes we observed was for the most part flexible and sensitive to students' emerging understanding (Anderson, 1989).

Explanations were clearly one of the striking features of the teachers' lessons in the classes we observed; however, we also noted the way in which teachers used various tools for enhancing discourse (NCTM, 1991). For example, in most classes students used calculators to do computations for word and other problems they were solving. In Mr. Cheing's class, he taught a strategy for solving equations that took into account the way in which most calculators order operations. In Mrs. Hutniak's and Mr. Smith's classes the students routinely used their calculators to do computations which came up in the large group discussions. There wasn't a teacher who did not encourage the use of pictures or diagrams when students were solving problems. Teachers also modeled how tables and graphs could be used to help one understand problem situations and find solutions to various kinds of questions in various mathematical situations. In a few cases, the teacher used forms of dramatization and story telling to engage students thinking.

The NCTM's *Professional Standards* discusses the importance of using tools to enhance discourse. They suggest computers, calculators, concrete materials, pictures, diagrams, tables and graphs, invented and conventional terms and symbols, metaphors analogies and stories, written hypotheses, explanations and arguments, and oral presentations and dramatizations are all possibilities for teaching mathematics. The teachers in our study successfully used these kinds of tools—no one teacher used all of these tools, but all of the tools are accounted for in the practices of the group as a whole.

Preparedness for teaching

Teaching is an intentional activity: a deliberate act. Enough cannot be said about the extent and ways in which the teachers in this study are prepared and prepare to teach. The teachers that participated in this study were well prepared for teaching mathematics to their students. This preparation came in many forms. All but two of the teachers in the study were either mathematics majors or minors and were considered by their schools to be mathematics specialists. All teachers, but one, have been teaching mathematics for a number of years. Many of the teachers in the study reported that they continue to attend inservice activities and read professional journals related to mathematics as part of their ongoing professional development. Further, the teachers knew the expectations of the curriculum not only for the grades that they taught but also for the grades that came before and after. One teacher commented that she could visualize how the mathematics from grade one to university calculus connected together. The principal/mathematics teacher in one rural school showed the researcher a chart in the staff room that lays out the outcomes from grade 1 - 12. In that school this is a deliberate attempt to have teachers integrate the teaching of various topics between subject areas.

Mr. Flynn, Mrs. Hutniak, and Mrs. Weslosky each have decades of experience teaching mathematics. Yet these teachers do not simply rely on the fact that they have taught "the stuff before." On the contrary, I wonder if these teachers are even more able to pick up on something new and incorporate it (whatever it may be) into their existing teaching practice. I am reminded of a remark by Mrs. Hutniak. When asked what she thought of the readability of the new text, she agreed with another teacher's comment that it is difficult for the students. However, for Mrs. Hutniak this wasn't a problem. She had the students read the chapter ahead of time. This also is interesting because the textbook she had been using previously involved little reading and many exercises. For this teacher, her teaching practice was under constant renewal; every time she faced a new group of students, a new textbook, or a new outcome to teach her teaching evolved. Mrs. Hutniak's teaching was made up of a set of practices that have evolved over thirty years.

Mr. Cheing, a teacher for 11 years, reported that he spends August each summer preparing a full set of class notes for the students. These notes include extensive illustrations, selections of problems that are not in the text and references to the test questions. Mr. Cheing passes these notes on to his students prior to the unit of instruction and the students use these notes, enriched by lectures and class discussions to learn their mathematics. Mr. Cheing was well prepared for teaching with detailed explanations, numerous examples and a selection of exercises and problems for students to work.

Mr. Wilchuk too plans ahead and is well prepared for teaching. Mr. Wilchuk has developed a system for planning in which day after day and year after year many of his lesson reflections are marked in his planner and remarked upon as he thinks back and forward to teaching. Mr. Wilchuk's planner and records from the prior year become his point of departure for the new teaching year. In his plans for future mathematics lessons many things stay and some things go. Each year Mr. Wilchuk's lessons are well prepared, informed from past experience, but developed with new students in mind.

Mr. Hilyar, mathematics teacher and principal, finds he needs to be prepared not only for teaching but for being able not to teach. As an administrator, he finds that he is often called out of his class; thus he must be prepared to leave his students almost at any time. In his class, explanations are given when he is in class, student tasks are well defined, materials are prepared, and his students are taught to work independently of the teacher—finding an explanation from a friend, offering help to another, learning to check on their mathematics on their own.

Mr. Albert, a relatively new mathematics teacher, must be well prepared. He is new to the school and has not taught the math 9s before. His colleague, Mrs. Dawson, has binders of materials, and the experience of having taught the course many times before. She shares her expertise with him. As an example of this, Mr. Albert was not familiar with working in a base other than base 10, so he sat in on Mrs. Dawson's grade 7 class to learn to work in base two. Mr. Albert depends on Mrs. Dawson and prepares for teaching by consulting with her and word processing her materials as a means of preparing for his students (and at the same time giving something back to Mrs. Dawson).

These teachers provide much evidence that to teach well one must be well prepared, but preparedness is not a final state; it is a state in anticipation of something. Further the preparedness was a result of experience, long range planning, day-to-day planning and the reflection upon one's own teaching practices. These teachers were constantly learning, changing, and developing their teaching practices in anticipation of teaching children mathematics.

Reflecting on one's own practice

"[T]eachers [need] to become aware of and regulate their own teaching strategies; that is, become researchers of their own practice. For this to occur teachers need to develop their own self-confidence with respect to mathematics and mathematics teaching" (Hoyles 1988, p. 164). The teachers in our study were self-confident both in their ability to do mathematics and in their teaching practices. For most of them, their teaching has been validated by strong student performance on the PATs, student and parent feedback, and collegial and administrative feedback. But, these teachers also monitor their own work. We found that a number of the teachers in this study are highly reflective of their own teaching practices. This is evident in the planning strategies of teachers like Mr. Wilchuk, but it is also evident in the practices of teachers like Miss McInnis who has a wonderful teaching portfolio under construction. Teachers like Mr. Cheing reflect on mathematics as a way of better understanding his teaching practice. The teachers in this study revealed by talking about their teaching practices that they were reflective practitioners. They also told us that one of the most important features of any inservice is the opportunity to share stories of experiences with their colleagues. Storying is another way these teachers reflect on their practice.

Ownership of the curriculum

The teachers in our study did many things well even though they did things quite differently. Throughout this chapter I have tried to indicate the variety of practices that we witnessed in the grade nine classrooms of the schools whose students performed well on the PAT. As we looked at those practices as a totality, the place and ownership of the curriculum begins to stand out. It stands out because most of the teachers in this study and many of their students behaved in ways that lead us to see them as taking ownership of the curriculum. The teachers and students talked about mathematics as though it were their own. Teachers selected examples and concepts to develop based on who their students are—their interests, abilities and prior experiences with mathematics—and how the teacher sees and understands the mathematics. The teachers did not seem to base their teaching on how they think someone else wants it taught or learned. We did not hear teachers commenting on "Alberta Education's curriculum," nor did we hear references that might lead students to believe that mathematics belongs to those who prepared textbooks or tests. The students and teachers in this study treated mathematics as their own, something they learn, think about and use as part of their lives inside and sometimes outside of the classroom.

The significance of context

It is important to comment on the context in which these teachers work. School location and class size although not controlled or influenced by teachers are relevant to this study. When we selected from the Alberta Education data base for class size over twenty-five students, 24 schools were identified as having strong performance on grade nine PAT in mathematics. All but two of these schools were in large urban centres. Recognizing a need to study the teaching practices in rural schools, we changed the class size criterion to more than six students and less than twenty-five students. When this was done all 22 of the schools selected were from towns and rural areas or were private schools. (See appendix C.)

In our study half of the schools in our target population involved relatively small class sizes—less than 20 students but none of the small classes studied were in urban schools. However, a couple of the large class schools were from rural areas. In both the large classes and the smaller classes, students were generally very respectful towards the teacher and other students, attentive in class and engaged in the tasks assigned by the teacher. There did not seem to be remarkable differences in the way the teachers approached the lessons given that they taught large or small classes. Although, in the very small classes teachers who worked one-on-one with students doing seat-work were likely to spend more time with a greater portion of the students in the class than the teachers in large classes.

Urban rural distinctions

The urban schools in our study are not in low socio-economic nor transient neighborhoods. They are for the most part schools in working class and middle class neighborhoods. The school administrators reported that the students are generally well supported by their families in many ways. The children needs are satisfied and generally a high emphasis is placed on schooling. The same can be said of the rural schools. Principals and teachers commented on how supportive parents were. In very small towns the school appeared to be the centre of the community. Little could happen in the school without it affecting the community and vice versa. In one town the school newsletter is an important way of sharing; in another town school news is big news in the local weekly. Repeatedly through the student, we were reminded of the contextual nature of teaching.

In all of the urban schools in this study the teachers and administrators told us that the community in which they teach makes a huge difference in terms of their results on the PATs. One school declined to participate in the study because they were not certain that their teachers would have the results they have had in the past because the school had undergone a boundary change and was now serving a different community. The principal at Bellcroft was very concerned that our study might lead other schools to believe that what his teachers do would work in their situation. He stressed that what works in his school works because of the particular community and teachers he has. He claimed there is no reason to believe that what his teachers do would work in schools with different circumstances.

In the rural schools, the teachers and administrators credited much of their success to the support they received from the community. Repeatedly researchers were told that the community had high expectations for success and would support the school to achieve those expectations. In these schools, teachers were more likely to comment on the hard work of their students, whereas in urban schools the teachers were more likely to comment on the students' ability and strength in mathematics. As indicated earlier in this paper, one of the distinctions between the urban schools that participated in the study and the rural schools is that the urban schools have enrichment programs for their students; thus a portion of the grade nine students in urban schools are studying mathematics content beyond the grade nine curriculum outcomes. We do know that the rural schools in our study did not have enrichment programs for their mathematics students; however, this does not mean that the curriculum was not enriched for students. Two of the researchers noted, that the teachers at Gilhooly and St. Al's go into great depth with the concepts they are teaching and foreshadow content that is forthcoming in grade ten.

One of the areas in which there appeared to be difference between rural and urban schools was with respect to program suitability and assisting weaker mathematics students. The urban schools with special programs were thought to be more conducive to strong academic students than for the weaker academic students. A few parents commented that their children found it difficult to keep up with the strong academic students and were intimidated by the atmosphere of the school and/or mathematics class. Parents acknowledged that teachers expressed a willingness to help the students who asked for help; however, the parents also indicated that their children did not feel comfortable taking up opportunities for help. This is quite a contrast to the comments made by parents of children attending rural schools. For the most part the parents indicated that their children were offered extra help anytime they needed it and that the teachers were very good about not going on with new mathematics until all the students had an opportunity to understand the current lesson.

Having pointed out the perceived role of the community and students themselves in the strong performance on PATs it is interesting to note that, in all of these schools the teachers were generally thought of as very good teachers. Administrators suggested they had "great mathematics teachers;" parents observations ranged from the teacher providing good explanations, offering extra help, to being very concerned about the student; students frequently said that the teacher explained things well and offered extra help. In all of the rural and urban schools we studied, the grade nine teacher(s) were identified as mathematics specialists. Further, all of the rural and some of the urban teachers indicated that they were likely to teach many of the same students for more than one year.

Some concluding remarks

In this study we observed teachers whom are committed to developing mathematics lessons in which their students must play an active role. Their students are challenged and work hard at trying to make mathematics meaningful. Teachers in this study demonstrated that there are many possibilities for teaching mathematics and doing mathematics with students in grade nine classrooms that will lead to success on standardized tests. Consider the very unusual treatment of mathematics by Mr. Cheing, creating uncommon methods of solution; Mrs. Dawson's personification of mathematical objects and her playful attitude towards such objects; Mrs. Hutniak's careful and detailed analysis of a solution to a mathematics problem; and Miss McInnis's diversity in her teaching practices, from rapping with her students to making connections between mathematics and their lives outside of school. From the teaching practices project we have learnt that teaching looks different from teacher to teacher, class to class and from community to community. But the teachers whose students have been successful on the paper-and-pencil PAT produced by Alberta Education over the past three years, and who participated in the study, do share some commonalties related to teaching practices and the contexts in which they teach. From reading the cases in Part 2 of this report, the following observations will become evident.

- The teachers help their students make mathematics real and relevant.
- The teachers are committed to teaching their students mathematics.
- The teachers place high expectations on their students.
- The teachers teach challenging mathematics.
- The teachers expect students to be active participants in mathematics lessons.

- The teachers challenge their students with hard, complicated and sometimes sophisticated mathematics questions and problems.
- Mathematical explanations are thorough and alternative explanations are often suggested.
- The teachers are well prepared and prepare well for teaching.
- The teachers know the mathematics they are teaching.
- The teachers go beyond the mandated curricular outcomes.

In the case studies that follow, we offer descriptions of some of the teaching practices observed in schools where students have had success on the PATs. By reading and reflecting on the cases teachers, administrators and teacher educators have an opportunity to learn more about teaching mathematics.

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Part two: The Cases

The Case Researchers

FLORENCE GLANFIELD

Florence Glanfield is currently enrolled in a Ph.D. program in mathematics education at the University of Alberta. To this research project, Florence brings experience as a classroom teacher; a curriculum development, curriculum implementation and student assessment consultant for a provincial ministry of education; an author of teacher and student resources; a consultant to many different school jurisdictions across Western Canada; and has a strong connection to professional mathematics education organizations.

Over the years, Florence has become increasingly fascinated with how teachers' understandings of mathematical concepts grow and change as new curricula is being implemented. Her doctoral research is using narrative inquiry to investigate this growth and change. You will see this perspective in the words of her cases.

In participating in this research study, Florence saw, in action, that teaching with meaning and for meaning means different things to different people. Critical to all of these perspectives was the role of language in learning mathematics and it did remind her of her years of learning mathematics. Florence will tell you that the way that she came to understand mathematics was when she was able to explain ideas to a friend. Florence noticed this 'explanation' happening in the classrooms she visited.

MARIE HAUK

Marie Hauk received her B.Ed., M.Ed. and Ph.D. from the University of Alberta, where she has been a sessional instructor in mathematics education since 1982. Prior to this, she taught at the elementary and junior high levels. She contributed to the development of Alberta Education Diagnostic Mathematics Programs and wrote illustrative examples for the Western Canadian Protocol. Marie is a past president of the Mathematics Council of the Alberta Teachers' Association (ATA).

The mission of Math Alive, her own consulting business, is to make the learning of mathematics meaningful and fun. She is committed to realizing this goal by publishing teacher resource materials and by providing professional development workshops and presentations at ATA Conventions, specialist council conferences and inservice sessions throughout the province. Through participation in this research project, Marie has a renewed respect for classroom teachers who regard themselves as ongoing learners and who demonstrate a passion for mathematics learning which they strive to share with their students.

RICK JOHNSON

Rick Johnson is a teacher on leave from Edmonton Public Schools. He has experience as a consultant in student assessment and mathematics, a teacher of elementary grades and resource rooms, and a University lecturer. He is presently coordinator for the Provincial Council of the International Reading Association and a director of the Mathematics Council of the ATA.

Rick is both intrigued by the paradox of teachers who do exceptional jobs in teaching complex content and yet seem not to be aware of how well they do this work. He has learned a few new ways to begin talking with teachers about teaching.

KATHY MCCABE

Kathy McCabe is a Field Experience Associate in the Department of Secondary Education, University of Alberta, mathematics major. She is seconded from Elk Island Schools where she has been employed for nineteen years as a high school math teacher except for the year she was seconded to Alberta Education. Kathy has done a lot of work with Alberta Education on both curriculum and assessment. She has also been very involved with ACCESS: The Education Station writing and presenting mathematics lessons.

In Kathy's job as a Field Experience Associate, she teaches the curriculum and instruction courses to the secondary mathematics majors. She also teaches courses on classroom management and lesson planning. Kathy supervises students in their second and third rounds of student teaching. She believes the experience of viewing future teachers has helped her in her role for this project.

Kathy believes the attitude of students has a great impact on their success. This belief is born out of her observations at Alan Lane School. The parents, teachers and students all expect good results and for the most part the students do well.

JOYCE MGOMBELO

Joyce Mgombelo is currently a graduate student from Tanzania in the Department of Secondary Education, University of Alberta. She is pursuing a Ph.D. program in mathematics education. Her research interest is in the area of teacher education particularly teachers pedagogical content knowledge. Joyce brings to the research an experience of a high school mathematics teacher, mathematics educator, teacher educator and researcher.

Readers of the cases will recognize the following element: each case of a teacher begins with an account of classroom interactions to emphasize that this is a study of the teachers' teaching practices as it would be viewed from everyday experience of the classroom. Readers are invited to read the accounts in themselves. It is hoped that practicing teachers will recognize elements of their own work. The second part of Joyce's cases include her reflections on her experience. In developing the reflections she was concerned with the particularities of each teacher as she/he brings the world of significance with her/his students. Readers are invited to read the reflections as the Joyce's answer to the question: What is unique about this teacher?

EMILE PINCO

Emile Pinco is completing a Master of Education at the University of Alberta. He brings to the project fourteen years of teaching experience in four countries: Canada, England, Gambia and Malawi. Over the past four years Emile has built up a successive educational business.

Given Emile's business, teaching and education background as well as his interest in teacher education, it is not surprising that he brought some very interesting insights into the project.

Emile writes that the teaching practices project has given him the opportunity to observe mathematics teachers from a new perspective; that is, looking for all the excellent things that teachers do as part of their teaching and relationship with youth. He was taken by how effectively many of the teachers are using the philosophy of the NCTM teaching standards without even realizing that they are doing so. The project has also given him the opportunity to work on his writing.

BRYAN QUINN

Bryan Quinn has been employed by the Edmonton Public School Board as a math teacher since earning his B.Ed. degree from the University of Alberta in 1975. Having taught math in all grades from 7 through 11, he has served as department head at the junior high level for much of his career. He has been actively involved in organizational committees of numerous mathematics competitions and has sponsored talented students for a variety of local, national and international competitions. As recipient of a NCTM grant, Bryan conducted action research in his own classroom regarding the learning of fractions.

Bryan gained a greater appreciation of student assessment during his assignment to Alberta Education for the 1988 - 89 school year. A long-standing member of the Mathematics Council of the ATA, Bryan spent five years as Executive Director and co-chaired its 1991 Annual Conference. A strong believer in the importance of professional development through collegial exchange, Bryan is a regular presenter at math conferences and Professional Development days throughout the province. He has co-authored various published teacher resource materials, including recent works approved for the Western Canadian Protocol.

His involvement in this research project has confirmed his conviction regarding the importance of teaching for understanding and the necessity of engaging students in authentic learning experiences.

ELAINE SIMMT

Elaine Simmt is an assistant professor of secondary education at the University of Alberta. She teachers both undergraduate and graduate courses in mathematics education.

Her research interests include mathematical knowing and the teaching and learning of mathematics. Elaine values the opportunity to do research in mathematics classrooms because it is in those classrooms that she finds mathematics emerging in the actions and thoughts of teachers and students. This research was particularly valuable because the teachers were so willing to help the researchers try to make sense of mathematics teaching.

SHANNON SOOKOCHOFF

Shannon Sookochoff is a teacher on sabbatical leave from Edmonton Public Schools working on a Master of Education in secondary mathematics. She has taught math, drama,

dance, health, film studies, and English to students ranging from grade seven to twelve. Shannon's commitment to the teaching profession has led her to involvement with the Alberta Teachers' Association in the areas of professional development and professional relations.

Shannon's involvement in this research project has affirmed her belief that "noticing" is the key to learning and teaching. The teachers she observed "take note" of their students mathematical conjectures and learning preferences. As well, the administrators in these teachers' schools work hard to really "see" and value the work of their staff. Teachers are trusted and celebrated. On that, Shannon is grateful for the question that guided her during her own school observations: "What are the good things that are going on in this school, and, specifically, this math class?" The question guided the kind of positive observation that she thinks could lead us all to better teaching practice.

Three

Saint Al's Catholic School

Elaine Simmt

St. Al's, a grade 9 - 12 Catholic High School of just under 200 students is located in a mid size town serving a farming community in central Alberta. There are two grade nine math classes. Both classes have 22 students and are taught by the same teacher—Mrs. Hutniak. They have approximately 120 hours of mathematics instruction during the year. Over the past three years the grade 9 students in this school have done remarkably well on the grade 9 achievement test in mathematics. According to Mrs. Hutniak, her grade 12 students also do well on the diploma exam. Mr. French, the school principal gives all credit to Mrs. Hutniak. When he was asked about the student's performance on mathematics achievement tests he immediately responded, "We have the greatest math teacher here."

Mrs. Hutniak

The Community's High School Math Teacher

Mrs. Hutniak has been teaching high school mathematics in this community for her whole career, more than 30 years. She is well known in the community, highly respected and greatly valued for her ability to teach mathematics to all students. She believes her greatest strength is that she loves kids and loves math. Students think she helps them by explaining things clearly and writing good notes. The parents indicated that Mrs. Hutniak cares about kids and explains math well. As a testament to her, 43 of 44 questionnaires were returned by parents. I spent two days at St. Al's watching this teacher teach her two grade 9 math classes.

Getting out of my car, on the first day of my visit, I was reminded that this is big sky country. The school is on the edge of town. Looking south and west from the school grounds I could see for miles over the open fields. In the other two directions were modest homes with large trees—a mature neighborhood. The school grounds were quiet when I arrived—the calm of the prairies. Although students were arriving by yellow bus and family cars, the calmness was not interrupted. As the students stepped off the bus they immediately entered the school. I followed a boy into the front doors; he nodded to me as he held the door open. Even in the school, I was struck by the calmness. There were students milling about the hallways, but the halls were not congested like I have experienced in some large urban schools. Maybe it was because in each hallway there was an enclave where lockers and benches were located. The students sat and stood around in those areas talking to their friends and digging out their books for their first class. I later learned that the building originally housed an elementary school; the coat rooms were converted into these locker areas.

Mrs. Hutniak's room resembles many I have seen before. The desks are lined up in rows facing the front board. On a side bulletin board is student work displayed under a banner announcing "Math Journals." Some student work, posters about integers and number systems made from paper clippings, hang on the board. On the other side of the

room there is a poster that lists steps for problem solving. The remaining walls are covered with inspirational messages. On the shelves at the back of the room are paper boxes, filled with materials for teaching— a tin of rulers, a binder of graph paper, and photocopies of handouts. Cans and string fill a box sitting on a shelf near the front of the room. On the teacher's desk is a binder with student materials and a recent issue of *The Mathematics Teacher.*

Mrs. Hutniak gave me a quick run down of what she would be doing that day: in period 1 introducing statistics, in period 2 her second set of grade 9s would arrive and they would go over the quiz they wrote last day, then later in the afternoon the first group of grade 9s would return and she would finish their introduction to statistics. The next day she told me the reverse would happen since she would be seeing her second class twice thus giving her more time then to introduce statistics.

Love Notes

> *As the students arrived for their first class of the day they did so quietly yet not silently. There was some chatter among the students, but it quickly came to an end as the students took to their desks and opened their books. As the students arrived Mrs. Hutniak was putting the finishing touches to the title of the new chapter up on the board. The students immediately took out their pencils and opened their notebooks—coiled notebooks to be precise.*

I came to learn that the notebook plays a very special function in this teacher's class. Mrs. Hutniak made a point of explaining to me how the students take notes in their coil notebooks in blue or black ink and any corrections are made with whiteout. The students' exercises are done in pencil so they are able to correct their mistakes. Throughout the lessons I observed, Mrs. Hutniak instructed the students as to how to take notes in their books. "Take out your ruler and draw this table, Pardon John? You need a ruler? Take one from the pail on my desk. If anyone else needs a ruler go and get one. I don't want to see any messy tables," she cautioned them. In another instance when she picked up a piece of blue chalk to note for the students which two numbers were being multiplied together, the students followed suit and took colored pencils to make the same notation. The homework that Mrs. Hutniak assigned was also written in the notebooks— in ink and then highlighted with a marker. "This makes the assignment easy to find when they get home," Mrs. Hutniak said. "They have no excuse for not knowing what they are supposed to do for homework." Her 32 years of experience was manifested in many of the managerial and motivational strategies she used in her classroom.

Mrs. Hutniak warns her students that if they miss a class they will have to get the notes from another student in the class, because "all of Mrs. Hutniak's notes are in her head," she said as she pointed to her head. But after having watched her teach and make notes with the students, I wondered if the notes the students take in class are Mrs. Hutniak's notes at all. The notes are created in class as Mrs. Hutniak interacts with the students in her large group discussions. She records the notes (and the students record what she writes) but the notes come out of student thinking as Mrs. Hutniak skillfully solicits from the students information, explanations, terminology, and student meanings. She simply records the students' notes for them to copy as they go along. I think the

reason Mrs. Hutniak cannot give the students notes if they miss a class is because they (personally) don't have any notes to record. They were not present, they did not contribute, they had not thought about the day's mathematics lesson; thus they have nothing to note. Because the students know how important their notes are, I trust that when Mrs. Hutniak suggests to one of them that they should get the notes from another student, they do so.

It was evident to me that the students took special care with their notebooks, but so did Mrs. Hutniak. She described to me how she collects them every second week, carefully reads through them, and then writes back to her students, each and everyone of them, each and every time. It is clear that this is a useful strategy for keeping abreast of what the students are doing—how attentive they have been in class, how much homework they are doing out of class, what they are able to do and maybe more importantly what they are having difficulties with. But for Mrs. Hutniak this is more than an assessment strategy. It is a way to make a connection with the students—to relate to them on a personal and one-on-one basis. After reading through their notebooks she writes back to the students pointing out their strengths and weaknesses, giving them advice and encouragement—"a love note," as she calls it.

It was clear to me that the coil notebooks mattered. The teacher/student relationship is written into those notebooks. The students' mathematics is brought forth in them and they become the source for and a record of the students' mathematics knowing. Even the parents recognized the importance of the notebooks. Parent after parent commented that the students reviewed their notes, studied their notes, read their notes. . . . The notebooks are a fundamental part of this teacher's instruction and her students' learning. Mrs. Hutniak patted one student's notebook, "You know, we will go through two or three of these this term."

One-on-one

> I always feel that before I can teach any student that I have to have some relationship with that student. There has to be a trust between us.
>
> Mrs. Hutniak

The notebooks were clearly one place in which Mrs. Hutniak took time to be in relationship with her students on a one-on-one basis. But I found myself looking for where else she managed to support the students with one-on-one. Many of the parents indicated on the questionnaires that one of Mrs. Hutniak's strengths is that she works with the students one-on-one. I was struck by this comment because after observing Mrs. Hutniak on the first day of my visit, I witnessed her fill the full 67 minutes with a teacher directed large group session. She told me later that day that this was not unusual and she led me to the front of the room to show me where she has worn a path on the floor in front of the blackboard. She said she believes it is her job to teach the students not to baby-sit them. When asked if they do homework in class she was emphatic, "No. That is why it is called homework. They do their homework at home." Sure enough all but one student indicated that they had math homework most days of the week.

I was confused. If Mrs. Hutniak spends most classes leading the students through explanations, examples, and problems, when are the students getting this one-on-one time of which the parents spoke so highly? I was determined on the second day of my observations to look for the one-on-one that the parents and students valued so much.

The second day of my visit to St. Al's I observed Mrs. Hutniak introduce the statistics unit to her grade 9B class. Like the day before the students arrived to class on time and took out their notebooks. On this day however, the students were still chatting when Mrs. Hutniak first spoke and as she wrote the title of the new chapter on the board.

"Sh, Sh," with this small signal the students stopped talking and focused their attention on the teacher. One boy with a broken arm and using a cane was standing and looking as though he wasn't sure where to sit. "What's wrong? You can't get comfortable?" Mrs. Hutniak asked. "Do you want to kneel on one leg maybe?"

"I can't sit back there," the boy said as he pulled a desk out of position to give himself more room.

"Do whatever is comfortable for you," the teacher said sincerely.

Turning her attention back to the whole class, Mrs. Hutniak said, "On your outcome statements it says that data analysis does not come to the very end, but in your textbook it comes right after the introductory chapter. So I thought we should do it now. It will be easier for you to follow along."

Mrs. Hutniak proceeded by writing the outcome statements for the data analysis chapter up on the board. The students quietly followed along and copied the notes in their notebooks. When she turned from the board she took a step to position herself at a boy's desk at the front of the room. She lowered her voice to speak to him. I could see her flipping through some pages in this notebook. "There it is. Write this down right here. Okay."

Without any hesitation she looked up to the class and asked, "I am first going to ask you a few questions about what you were supposed to have read in your textbook."

Writing on the board she said, "I am going to call this first part E1. It is a review and preview for data analysis." She wrote the key words as she spoke. "We are going to review some of the concepts you covered in grade 8 and we are going to look ahead at some of the things that we are going to do."

Turning to the boy she got started a moment ago, Mrs. Hutniak smiled and commented, "You are writing quite neatly in there aren't you?"

A girl behind him said something which Mrs. Hutniak reacted to, "You're doing a very, very good job Amy. I admire those people that don't give up easily."

"You're writing with your left hand," Mrs. Hutniak said to the boy with the cane and the broken arm.

"Yeah." He relied with an upbeat tone.

"That's pretty good. Okay," she turned her attention back to the whole group again, "I asked you to read pages 44 to 80. Jodie can you tell me two sentences about what you read?"

"I didn't read it," the student replied.

"You didn't read it sweetheart. Do you think you can possibly try to do it today?" she asked the student. "Who can I ask to give me two sentences? Two sentences."

A girl on the back of the class said she read something about graphs and then brought up the word 'scattered'.

"Scattered—"

"—plot," a few of the students said in chorus.

"Good and what else do you remember."

"Nothing. That's all I remember."

"Did you read it or just skim through the pages?"

"Yeah, but I didn't get done the whole chapter."

"Okay, anyone else? Trevor."

"Line of best fit?"

"Line of best fit. Good" The teacher repeated this term like she did with the term scatter plot. "And on what kind of graph do you find a line of best fit?"

"You estimate."

"You estimate, okay. We already used the term it's a —"

"—a scatterplot," replied another student.

"Very good. Anything else?"

"They plotted the Olympic best records."

Although a couple of students claimed that they had not yet read the book, clearly most students had read the chapter. They did not know the material but they were trying to recall words and phrases that did not yet have much meaning for them; but words that for one reason or another stood out for them.

"Who else remembers something? One sentence now. We'll go from two sentences to one sentence." Mrs. Hutniak paused just briefly giving the students a moment to collect their thoughts and offer a response. "Troy. Save my life. What is one thing you remember?"

"I read it all."

"One thing sweetheart. Just one thing."

"Um—it shows exercises and questions."

"And these questions pertain to—"

"Uh—like—"

Mrs. Hutniak did not persist. Instead she offered him a way out of his difficulty. "Scatterplots and graphs?"

"Yeah."

"Is there anything else?" This time the question was not directed at a particular student.

"Random sample."

"Yes and what does random mean?"

"Not in order."

"Okay. What else? Let's think about this. What if there is someone from the university who wants to do a survey. She wants to know if Mrs. Hutniak is a good teacher. And she wants a random sample of students to answer her survey. So Mrs. Hutniak picks Susan, and Louise, and Douglas, and Carrie to answer the questionnaire." The students began to smile. A few were chuckling. "What's the matter?" Mrs. Hutniak asks with a grin.

"It's not random. Those are all the smart kids."

"Ah-ha! It's not random. That is not going to give accurate information. Is it?" Mrs. Hutniak had made her point but before she left the notion of random she explained. "Random means that each one has an equal probability of being selected."

It was only when I began to look for one-on-one that I started to see it. It was there all along but I had not been attentive to it. Before observing these classes and reading the comments of parents and students, I had very specific ideas as to what one-on-one meant. For me, this meant working with a student individually—tutoring is probably the closest I can come to naming it. The parent and student comments alerted me to observe differently and when I did, I could see what they saw and what they experienced in Mrs. Hutniak's mathematics class.

Throughout the lessons I witnessed highly interactive classes. Although Mrs. Hutniak spends most of the 67 minutes of the class in front of the board, she is not doing all of the talking nor all of the thinking. The students in her classes are very actively engaged in the lessons. She leads the discussion but her leadership is from within the group. As students participate and respond to the mathematics Mrs. Hutniak moves with them, pausing to help a student find his page, helping another find a word to describe an idea or a thought. Even in this large group setting I saw the highly personal and individual attention she gives her students. In a single class most students were called on by name and in a most respectful tone. Mrs. Hutniak responded to many of their questions with an endearment. She took 20 seconds here and 30 seconds elsewhere to quietly interact with a student, often about mathematics but sometimes about something besides mathematics: the health of a friend or parent, an upcoming community event, or simply about how the child feels that day. The beauty of these brief personal interactions is that they help create the relationship that this teacher notes is necessary for her to teach these children.

Many of the mathematics examples I observed Mrs. Hutniak use in her lessons involved a personal connection for one or more of the students in the class. In one case she talked about testing seed to determine the percentage that germinates (one boy pointed out this was his job each year late in winter). Another example involved the

Olympics (which were just over at the time of my visit). Yet another example involved cutting a big lawn. I was quite surprised to learn that one of the examples created in class by a student involved the teacher's two grown children.

Both the parents and the students value Mrs. Hutniak as a mathematics teacher. Numerous parents and almost all students commented that she helped and helps them (Mrs. Hutniak has taught a number of the parents, too) learn mathematics by giving them one-on-one and that "she explains until everyone understands." "She never gives up on us." These last two comments are related to this theme of one-on-one and are exemplified in the following situation. On my last day in the interview with Mrs. Hutniak I asked her about a couple of boys in her 9B class to whom she seems to give a lot of attention. "Oh. Yes," she said. "Well, I have six boys that are in the behavior modification class. Did you notice Trent? He was the one that gave the example in class. He is doing so well. And there is Greg and. . . . These boys come to my math class, but they are in special classes for everything else. I don't need to have them in my math class but I want them. How are they expected to learn mathematics if they don't come to my class?... I give them extra attention. I measure my success not by how well my students do on the achievement test but on how much they improve. That is my job. When they start here," holding up one hand, "and end up here," holding up the other hand. "Then I have been successful. And you've got to be able to do that without hurting this," she said as she put her hand to her chest.

Putting muscles on the skeleton

Helping students understand to achieve is Mrs. Hutniak's goal. And she uses many instructional methods. The math quiz is one example. It is a common experience for students in mathematics classes everywhere. Mrs. Hutniak's class is no different in this regard. But the quiz itself and how it was used in her class was quite different from that with which I am most familiar.

Quiz

1. A swimming pool is filled with three pipes. The larger pipe can fill the pool in 12 hours. Each of the smaller pipes fill the pool in 18 hours. How long will it take to fill the pool with all 3 pipes?
2. 32 is _____ percent of 75?
3. 24 is 37.5% of what number?
4. 65% of 75 is _____?
5. A brand of cereal is giving away prizes. There is one of four different prizes randomly distributed in each box. On average how many boxes of cereal would you have to purchase to get all 4 prizes?

Fig. 1

This episode comes from early in the term when Mrs. Hutniak was establishing her expectations. The quiz itself had only five questions but it was marked out of 45 (see figure 1). "I like to give lots of marks for each question," she told me. "That way I can reward the kids for what they can do and what they do know. Right now, some of the students are having difficulties with the problems and they don't know what I expect of them, but by the end of the year they will be able to do them just so."

The second group of grade nines arrived almost as quietly as the first. The students immediately took to their desks and Mrs. Hutniak began to pass back a quiz that they had written the previous day. As she did that she asked a boy in the class to pass out the journals. The journals were duotangs that seemed to be used to hold anything that was not written directly into the coiled noted books.

She told the students, "Now some of you, I gave you a little bit of extra marks. But your "let statements" weren't perfect. But since this was the first time that you were doing problems for me, we have had only nine classes, I was rather generous. Even when your statements were not quite perfect, I still gave you marks. But the next time you do this they will have to be perfect. After I go through the corrections on the quiz you will know specifically what my expectations are. There will be no excuse, no grey area. So next time . . . they will have to be perfect. After I go through the corrections on the quiz, then you'll know my expectations."

Although the quiz had only five questions, two of those questions were (what I believe to be) very difficult word problems. The three other questions on the quiz were reasonably straight forward percentage questions. Like I have done many times in my own mathematics class, Mrs. Hutniak informed the students that they were responsible for making their corrections. She had a very elaborate system and needed to direct the students with respect to how they were to complete the corrections.

"For those of you who have 40 - 45 marks you only do the corrections once. Between 35 and 40, do the corrections twice. Once with the problem on the quiz and then go to your text book and find another one like it and do it. Or you can make one up yourself. If you have less than 35, then you do it 3 times. Once, with the question on the test, and 2 from the textbook. If you can't find one then ask me and I'll help you."

"Now let us look at question number one."

A boy on the other side of the room from me asked, "What if you have 40?"

"If you have 40 just do it once. Okay we are going to go through these problems. Just as if you are going through them the first time. Now I am going to quickly do problem solving strategies. Travis when you are given a problem, any kind of a problem, what are two questions which you ask yourself?"

"What formula do I use?" Travis offered.

"What formula do I use. Yes. But even before you ask yourself what formula do I use?"

"How am I going to write it out."

"How am I going to write it out. Yes, but even before that?"

"Visualize it?"

"Visualize it, yes. Excellent. But even before that. Those are all very good, Travis." Mrs. Hutniak reassured the boy.

"Write a 'let-statement'."

"Before the let-statement." She pauses briefly and then turns to another student. "Michelle?"

"What is the question asking?"

"What is the question asking," Mrs. Hutniak repeated for emphasis. "What is the question asking? What am I to do?"

"What information is given," suggested yet another member of the class.

"What information am I given and— What else?" Mrs. Hutniak continued to probe. There were a couple more suggestions before one of the students provided the response for which Mrs. Hutniak had been probing.

"And what information am I asked to—

"Find," said a girl beside me.

"—find," Mrs. Hutniak repeated immediately. "Now I am going to look at this chart inside there. Let's look at that 'the steps to solving problems.' This is very very basic and then later on I am going to give you a handout with all kinds of steps, but these are the basic steps." She added in a pleased tone, "all of your answers are correct."

"Step A on the chart says, 'read the problem carefully.' Now I don't think anyone can read these problems just once. I couldn't and I have been teaching math for a long time." Mrs. Hutniak spoke slowly. She did not rush through her lesson. "Read the problem carefully. Read it once just to get acquainted with the words. Read it a second time and ask yourself what is this problem about. Is it about apples; is it about oranges; is it about the Olympics?" She paused as though giving each student the time to think about what the problem is about. "Read it a third time and then answer two important questions: number one, what information are we given? What information in that problem am I given? And if you can answer the next question, what am I asked to find, then you can begin. Once you answer those two questions then, like Travis said, you have to find some sort of equation, some kind of formula and then you should have to estimate the answer. What makes common sense? Because for each of these questions there has to be some kind of estimate and then work out your equation." Going back to the students she asked, "and what should you do after you work out your equation?"

"You check your answer."

"You check out your answer." Mrs. Hutniak agreed. "And how do you always complete every problem? You always write a complete statement. You always have to write a let statement. But where do you get your information for a let statement? Okay, now let's look at number one."

Mrs. Hutniak read from the quiz slowly. "So, a pool can be filled with three pipes. The first pipe will fill the pool in twelve hours. the other two pipes can each —now notice I have underlined the word each—fill the pool in eighteen hours. How long will it take all three pipes to fill the pool?" Mrs. Hutniak paused, looked around the room and asked, "Zhar, what are you given? What information are you given?"

"You are given how long it takes the large pipe and the small to fill the pool," the girl replied.

"Now why is it important for her to say the two smaller pipes? What might some students do? Jodie?"

"Because one is bigger."

"Okay, but what else might some students do because I only gave them two numbers? Kimberly?

"They might use only two pipes."

"Okay, and how many pipes do you actually have in that question?"

"Three," the girl replied correctly.

"Do I have to write this one down if I got it right?" a boy at the back of the room interjected.

"Yes. Everyone is to write this down. This way you will have the problem worked correctly in your journal and you will be able to go back to it when you are working on other problems like these. This counts as doing the correction once. So those of you who only have to do the corrections once, you will be finished your homework."

Mrs. Hutniak led the whole class through the problem by first having one student say what should be done next and then by having another student direct her through the particular step. Bit by bit, the students, under Mrs. Hutniak's carefully directed questions, worked through a solution to the problem and as they did Mrs. Hutniak kept track of every step on the board. The students followed suit. On their sheets they appeared to be recording everything Mrs. Hutniak noted on the board. They even took out a pencil crayon when Mrs. Hutniak switched to a piece of blue chalk to highlight how she changed the numerators of the fractions when she computed some equivalent fractions.

This problem took the class 25 minutes to work through, not because the students were inattentive or had trouble with offering suggestions on how to proceed but primarily because, as part of the process, Mrs. Hutniak constantly reminded them of what they should already know, pointed out shortcuts and techniques to use and questioned them as to why she was doing one thing or another. Each step in the process was carefully articulated and thoroughly discussed. I should have expected such detail. Earlier that day, when I first met Mrs. Hutniak one of the first things she told me was, "Mathematics is more than a skeleton; you need to put muscles on it."

Even after the question was completed Mrs. Hutniak still had more to tease out. "What are some other problems that are like this one? Give me some

examples." When the students did not respond she gave an example, "What about painting a fence? If it takes one worker 5 hours, another worker 8 hours and a third worker 7 hours, how long will it take all three to paint the fence if they work on it together. That is a similar problem. Now can you think of another one?" Some suggestions were quietly offered, but not loud enough for the whole class to hear. "Christopher, can you make a problem up." And with that Mrs. Hutniak took another 5 minutes to write out the problem that Christopher suggested.

An Exemplary Teacher

It is difficult to make a list of good teaching practices—maybe impossible. What is a good practice for one teacher may not work for another. Yet it is so clear to me that I was observing a 'master' teacher and I know that I have witnessed a genuine act of teaching.

What is it about Mrs. Hutniak that makes her a master teacher? What is it she does? In reflecting on my observations of her lessons I obviously have identified some elements of her teaching that I feel are critical to her success: engaging students in highly interactive lessons; teaching them to "take note" and reflect on their learning; fostering a personal relationship with each of the students; and interacting with her students one-on-one. These are the things I pointed to in this case but from the vignettes I have offered, I anticipate other features of exemplary teaching will be identified as readers try to understand Mrs. Hutniak's teaching practices.

In trying to understand better what is special about this teacher I asked Mrs. Hutniak herself about her teaching practices. She offered many insights that I could not know from just observing her classes over a couple days. I will conclude with some of her comments.

"If I didn't love kids, I couldn't be a teacher—and it's got to be unconditional love. . . . But it is also important to have a very good background knowledge in mathematics. . . . I can make connections. I can close my eyes and take it right from grade one right up to university calculus. . . . [The tests don't drive my teaching] because otherwise I would not be doing some of the things I am doing. . . . And I think, if I do it the right way, put interest into it, then the results take care of themselves. . . . I have to interact. I teach two grade nine classes math but each class is different. Maybe you noticed even the examples are different. . . . I've always loved math. I prefer math to sex. I always tell my students, I get a lot of satisfaction out of a good application problem."

Four

Alan Lane Elementary/Junior High School

Marie Hauk

Bryan Quinn

Alan Lane School was visited by two separate research teams; one was assigned to observe Mrs. Dawson, the second to observe Mr. Albert. The school accommodates about 750 students from kindergarten to grade 9. One class of each elementary grade accounts for 185 students; and the remaining 575 students make up seven grade 7 classes, seven grade 8 classes and six grade 9 classes of about 28 students each. In terms of location, the elementary students are clustered on one side of the school, and the junior high students on the other.

Although Alan Lane School originally was built in the mid-fifties, it has since undergone expansion and some renovations. It is situated in a pleasant, stable, affluent residential community. All but one of the parents who returned questionnaires indicated that they had lived in their current residence for more than three years. Most of the parents who responded had some post-secondary education. Also, about half of the respondents reported their family income to be greater than $60 000. Only one indicated an income of less than $40 000.

As researchers, we soon realized why Alan Lane School was selected for this study. The interplay of numerous factors has resulted in a learning environment conducive to achievement of excellence. Designated as an Academic Challenge (AC) site, Alan Lane School has two academic challenge classes in each junior high grade. The emphasis on excellence attracts many students and the school adheres to the district admissions policy. Generally speaking, priority is given to students who live within its boundaries and to students with special program designations (ESL, Academic Challenge, and as of next year, Mandarin). Next, consideration is given to siblings of current students. Since the school generally has far more applicants than spots, a lottery system is then used to fill it to its designated capacity.

Upon entering Alan Lane School, one notices immediately the focus on excellence apparent in the *Wall of Fame*. It dates back to 1982, and celebrates the many honors and achievements attained by the students. Students are encouraged to do their best in all aspects of school life, including athletics, science fairs, math competitions and other extracurricular activities. While every subject area is regarded as important, special emphasis is put on the core subjects, a natural consequence of having a significant portion of the student population involved in an Academic Challenge program. As much as possible, teaching assignments at the junior high level are based on subject specialization. Within each department, teachers work together, sharing a variety of materials and teaching techniques to motivate learning.

An atmosphere of mutual responsibility and support among students, teachers, administrators and parents sets the stage for success. The principal expects the students to achieve and this emphasis permeates through the school. The teachers expect results

from their students and they work hard to help their students to perform to the best of their abilities. The parents are generally very involved in their children's education. Staff members make frequent phone calls home and parents feel comfortable to contact teachers with any concerns.

Marie Hauk

Bryan Quinn

Mrs. Dawson

Striving for Excellence

The plaques have been filling up the walls so quickly in recent years that a more suitable description may be *The Halls of Fame*. As a result, more stringent criteria are now being applied to deem attainments worthy of posting. In the past four years, this urban elementary-junior high school has grown from 420 to 750 students. One reason for the population increase is the AC program, which now is in its fourth year. (There are two AC classes each in Grades 7, 8 and 9.) Describing the stability of the population, the principal, Mr. Albright, said:

> We probably have 40 or 50 kids move in and out of the school the whole year; more in the junior high, because they feed from a wider area – some more blue collar areas; and you know, this area is more white collar. They're pretty stable in this immediate geographical area, but the kids that come (the farthest), they're probably a little more transient."

Commenting that she has taught some students for three consecutive years, Mrs. Dawson, one of the junior high mathematics teachers, emphasized the importance of her contribution, by saying, "So, if they don't know anything in Grades 10, 11, 12, I'm the only one they can blame," and then she added, "I haven't had one come back yet!"

Accountability

The motto, *Strive for Excellence*, prominently displayed on the bulletin board in Mrs. Dawson's room, aptly describes her expectations which are shared by many of her students. Setting the tone for high standards begins with the requirement of an organized notebook. "I'm pretty fussy," Mrs. Dawson admits, as she described in detail the one and one-half inch binder divided into five sections for notes (color-coded), exercises (highlighted titles, textbook page numbers, dates), problem solving (spontaneous problems on board, problem-of-the-day, separate problem solving sheets), tests (all signed by parents), and paper supply. Her AC students have a sixth section for math contests and challenge sheets.

Student accountability in this regard is monitored by a binder check each report card period. Students have a week to prepare these notes and are provided with an outline to guide them, based on a notebook "from a student who is an immaculate note-taker". All the notes have to be accounted for, and every note entry will be worth two marks if the following criteria are met: they are neat, they have a title, the date is there, the title is highlighted, and they're done with pencil. In the exercise section everything's numbered, and two marks per exercise are given if: it has a title and a page number, it is done according to instructions, it is done in pencil, it is done neatly, a ruler is used where it was

requested, and there are reinforcements on the page. Mrs. Dawson's beliefs in the importance of organization are clearly expressed in her purposes:

> Why do I do this? (a) I think notes are extremely important to teach them to note-take and (b) to keep organized. If they can't be organized, they won't be successful, especially if they're average students, and also for study purposes so they have something to study from; so I give them a good set of notes and so that they can use it as a good reference whenever they have to look anything up in their notes. So, it's all organized. Once we do one term those notes are taken out, put into a brown paper envelope and put on a shelf at home and on we start with term two. It's an easy mark for them, and if they're not good, they sure get good in a hurry!"

Further incentive is that a well-kept notebook is worth 10% of a student's report card grade.

Setting a Standard for Success

Mr. Albright expressed belief that the AC program has a positive effect on student achievement in general, "They're [AC students] pretty focused and pretty motivated. It's good modeling from there. Our greatest effect has been in improving our benchmarks." Further acknowledging that an important aspect of her school's high math achievement is the students themselves, Mrs. Dawson said:

> We attract some very, very top-notch students here. They have a huge interest in pursuing their education, so they will do very well in mathematics. And if you take a look at the AC classes, they usually bring with them a high degree of intelligence which is very nice to work with.

The school, however, does not focus specifically on math, as Mrs. Dawson explained:

> Our school really specifically focuses on everything, I think, because we have specialty areas in every single subject. The focus is not really on any one particular thing, but on everything. And so, the expectations here are high, from both the administration and the parents. Last year we had 37% of our (Grade 9) students get Standard of Excellence and that's pretty high. ... So, now that we're 37%, I think our principal's going for 50%. The focus on everything is pretty high, but we definitely get support in teaching the academic subjects.

Mr. Albright, who describes himself as "a principal who tries to be a strong leader in his school, believes his school's academic success is not due "to any one thing," but rather reflects the "big picture" or "the big ball of wax." He explained, "I think it's the whole picture, and it's a different type of kid – you know – it's a pretty academically focused kid." He also was frank about the importance of academic subjects: "I always do emphasize the core and there's no question, you know. I pound that into the kid – core subjects are important, important, important! And when we have an assembly, I never give up on that!"

He makes it clear that students are expected to give their best effort. Regarding next year, he said, "There are some kids who are not returning here and some kids I'm

asking not to return because they haven't been trying in their school work." Homework is basically a teacher issue, but if students marks aren't "up there," he may play a role:

> I've got a number of students who I have lunch-hour tutorials with because they've got one or two core subjects under 50% and they've got a 55% or lower average. They have tutorials with me three times a week, and that seems to be doing the trick with some kids. They bring in their work and they just sit down and work. They are the kids who are very guilty of not giving an effort; they're not getting their homework done. They just need a little pressure and that's what I supply – not that they aren't able - they just need to get cracking.

Math Contests

The school has achieved tremendous success on national and international math contests primarily due to the involvement of its AC students. In this regard, the AC program incorporates ongoing formal training of its students as part of their scheduled math classes throughout the Alan Lane School year from September to May. Critical thinking skills which Mrs. Dawson calls "Higher Order Thinking Skills" (HOTS), are incorporated strictly into her AC classes. Every Friday is Contest Day. Students work in pairs or threes, "sharing questions, sharing ideas, solving problems together." What they don't finish in class, they take home where "they can tap into other resources," meaning that other people such as parents, brothers or sisters may assist them, but not do the work for them. Students are given a week to work on old contests. The following Friday, they quickly correct the questions, and have about 15 - 20 minutes to ask about any they had trouble with. "They get enthusiastic about it," said Mrs. Dawson, "because they really, really want to do well" and because their scores account for a small component of their report card mark. Mrs. Dawson explained how she helps them to strategize:

> I teach them how to attack and tear apart a problem, and it's all condensed into one word –*shortcut*, because these problems are rather difficult, and would take a very long time. So what you want to do is establish shortcuts for these students; methods of attack for these kinds of problems, where it looks impossible, and yet, within 30 seconds you can solve it, knowing some type of strategy or shortcut. So we deal a <u>lot</u> with shortcuts, to the point where, after a while, they get pretty good with it. They can see it from all angles, because there's so many different ways of attacking that we've probably covered.

While students not in the AC program may participate in current contests, they do not have the advantage of these in-class training opportunities.

Facilitating Student Learning

In mathematics, excellence in learning is facilitated in a number of ways: by the assignment of math specialists in every grade at the junior high level; through collaboration of teachers within the math department whereby materials and teaching ideas are shared; and by making available a plethora of manipulative materials.

Subject Specialization

Mrs. Dawson expressed her belief that subject specialization is one of the reasons students at her school do well on provincial exams:

> We have an excellent opportunity in this school to specialize in our subject areas which means that we are teaching only one subject at the various levels which gives us more time to focus on that subject area. The people who are teaching math here are people who have math backgrounds and that is a very, very important part in teaching mathematics.

Of the six teachers in the junior high math department, two are full-time math teachers, one teacher's assignment is half-math/half-computers, and the other three have different majors but each teach one class of math. Mrs. Dawson commented that one of the affective consequences of specialization is having the students enjoy math: "I think our whole math department exudes confidence in math and likes the subject; and of course, that is going to transfer to the kids." All junior high classes have math every day for a total of about 250 minutes per week. This equates to approximately to 150 hours per year, which is high with respect to the minimum of 100 hours of math instruction required by Alberta Education.

Variety of Materials and Teaching Strategies

Crediting "the wide variety of teaching techniques" as another factor in successful math achievement, Mrs. Dawson said:

> We have every kind of manipulative you can think of which we use with our students. We always teach to the student which means that if we see that the student needs help with a certain concept we use manipulatives or hands-on. We use various teaching techniques to help a student, we also have in-school help - the student is comfortable to come for help, morning, noon or after school.

When asked to comment specifically about incorporating manipulatives in Grade 9, she referred to using algebra tiles for her work with polynomials and equations; Unifix blocks for 3-D perspectives; tracing paper for transformations and measuring in trigonometry; dice, cards, marbles, and cubes for probability; and skewers and marshmallows for constructing 3-D models.

Mrs. Dawson has a variety of models that she uses to demonstrate concepts and skills. One of these, which she has named *Fred*, is a 12-sided polygon made of specially hinged congruent wooden strips. *Fred* can be manipulated to form, among other figures, *Sam* the square, *Rita* the rhombus, *Ron* the Rectangle, *Pearl* the parallelogram and *Tom* the triangle. In one of the lessons observed, she used *Fred* when reviewing the formulas for areas and perimeters of the aforementioned figures. The strips that enclose each of the figures exemplify perimeter as a linear measure. To conceptualize area, Mrs. Dawson told the students to imagine that the figures were rooms that they were "carpeting".

Another type of demonstration model consists of a set of four pairs of hollow plexiglass polyhedra (triangular, rectangular, hexagonal and octagonal prisms and pyramids with bases and heights congruent to those of the corresponding prisms).

Mrs. Dawson refers to the prisms as *moms* and the related pyramids as their *babies*. The following scenario, taken from the last lesson observed, shows how she used these models to demonstrate the relationships between volumes of prisms and pyramids.

After reviewing formulas for finding volumes of various prisms, Mrs. Dawson addressed the class: "Today, we're going to look at figures that look like this," she said while holding up some models of prisms and pyramids.

"Now, here's Mom, triangular prism," she said, holding one up, "and here's Baby," she said, while holding up its related triangular pyramid.

She then placed Baby beside Mom. "Now, notice: same base – triangular base. Now, you see there's height in the family. Is the baby just as tall as the mom? Remember, height is straight down."

Holding the bases of the two figures together to demonstrate that they are congruent, she said, "OK now, this base equals this base. That's why we can talk about them, because they've got something in common."

Similarly, she showed a Mom and the Baby having square bases. Holding up the two babies, she asked, "Now, what are these called?"

Over responses of both "pyramids" and "prisms," she, herself, replies, "pyramids." Mrs. Dawson continued: "Now we know that this (pyramid) is a fraction of that (prism), don't we? It's got to be. It's not the same size."

"Where's the Dad?" piped up a voice from the back of the room.

Quickly, Mrs. Dawson responded, "The Dad? I don't know. He's at large – took off!"

And the same voice replied, jokingly, "What a deadbeat!"

Holding up a Mom and Baby with octagonal bases, she said, "Mom, Baby, see that – octagonal prism, octagonal pyramid. Now, your pyramids are all called by their base again."

"Now let's look at these three little guys [the pyramids]," she said, removing the prisms.

"What do they have in common? They have the same height. OK, what else do they have in common, Mel?"

"If you put them all together, they'll all make one of those," interjected Clarice.

"No. Mel, Mel …," Mrs. Dawson responded.

Mel answered, "They have a point on top."

"Right," agreed Mrs. Dawson, " Does anybody know what that point is called?"

"Vertex", called out a voice.

"Vertex," Mrs. Dawson repeated, "It actually has a special name. It is called an apex. Can you see anything else they have in common?"

Again Clarice piped up, "If you put them (pyramids) all together, they equal one of those (prisms)."

"No," responded Mrs. Dawson, "They can't because they have different bases, but I know what you are saying because there are three of them."

Anna said, "All of their sides are triangles."

Mrs. Dawson pointed to each pyramidal face while saying, "triangle, triangle, triangle ... So now we're going to look at volume."

Referring to a cylinder/cone pair, Mrs. Dawson commented, "Their formulas (relationship of volumes) is going to be very much the same."

"OK, now here's what we're going to do," explained Mrs. Dawson as she stirred red food coloring into a pitcher of water.

"I'll fool around a little bit more here ... Got my morning juice here ... Now we're going to do some physical proof here, just so that you'll remember and that you'll know for sure how to find this."

Writing V=Bh on the board, she commented, "We already know this." Pointing to the written B, she said, "we are looking at four different bases here."

Holding up the triangular prism and pyramid, she said, "Now we want to know how their volumes are related. You can guess - you've already seen it on the computer."

As she consecutively filled and dumped the triangular pyramid into a jug, three times, Mrs. Dawson jokingly offered, "Whoever guesses the right answer gets to drink this later, just for a treat."

Raising the jug and triangular prism, she asked, "Do you think this will fit in here, or should I do another one?"

Amid a variety of responses, she slowly poured the water from the jug into the triangular prism, asking, "If it is three of these, what would my formula be?"

A voice called out, "One-third." "Ah, one-third what?" she asked.

"Bh," the voice replies.

"Now isn't that easy," said Mrs. Dawson, "One-third Bh, and of course, we all know we don't like to work with thirds because that's a point three repeater, so an easier way would be to say Bh divided by 3."

Finishing her pouring, she exclaimed, "All right! So you all win, so you get a taste of this after class."

A barely audible voice responded, "I'll pass."

Action Research Experiment

Instead of using a textbook, Mrs. Dawson began this year with her two grade nine classes on a computer-based program, *The Learning Equation* (*TLE*). The computer lab is reserved for her classes to permit her to bring them in every day. The program was implemented with her regular class and her AC class so that there would be contrast groups when assessing the program's effectiveness. The *TLE* CD provided both instructional and self-check components, and an accompanying workbook was the basis for homework assignments to be handed in and marked. Early in the year, she discovered that this computer-based approach itself did not fully meet the needs of her students. She still finds it necessary to provide her classes with review and practice of prerequisite concepts and skills, as well as an introduction to new topics before having the students go on the computer. Further, she feels that homework on new topics from the *TLE* workbook often need supplementing with additional assignments (extra worksheets given as homework). As the self-check scores are not on a server, she relies on the students to report their own scores using an honor system. The need for tests written in the classroom has not diminished due to limitations of the assessment portion of the CD. Students work independently or in pairs, proceeding at their own pace through the assigned section(s). Mrs. Dawson explained what happens in the lab:

> One operates the mouse one period and the next period the other student operates the mouse. They share ideas as they're working on each screen. In other words, they're solving problems together and collaborating on answers. They tend to discuss the answers before they punch them into the spaces. It seems to work quite well. A lot of math dialogue is going on. You'll notice when they're in the lab, you'll see total focus and concentration – most of the time, anyway. It's complete interaction between student and computer so they're always concentrating on whatever they are doing and interacting continuously. If they should be finished a lesson, one will go and work on their exercise, either a sheet that I assign or a page from the *TLE*, and the other one will work on the self-check. Self-check is a little test that they take at the end of the lesson and they enter their score in my green binder.

Gesturing to the class working diligently behind her, she remarked, "So this is the 1990s computer classroom that you see!" To a spectator walking around the ring of 17 computers, a typical session in the computer lab looks like this:

> The same computer-generated female voice can be heard saying different things to students who are at different places along the programmed learning sequence. For example:
>
> Computer A: "Enter the perimeter of the two by eight,"
>
> Computer B: "How can you describe the area of each rectangle?"
>
> Computer C: "How can you describe the perimeter of each rectangle?"
>
> Computer D: "Now complete the rest of the table."
>
> Intermingled with this, you might hear student dialogue as follows:
>
> Student V: (pointing to the screen) "That's 34 + 26 is, um, 60."

Student W: "I'm out of paper."

Student X: "Look, you guys can do it yourself."

Student Y: "You're asking him? Or are they asking you?"

Student Z: "Oh, look. What's the answer? It's not this."

Mrs. Dawson monitored the students continuously, offering encouragement, giving hints, working out problems with students experiencing difficulty, and troubleshooting technical computer glitches, as revealed by one particular situation:

Sigmund (with his hand raised), complained, "This isn't working..."

Mrs. Dawson responded, "Keyboard's frozen?"

Talking to the camera, she added, "And then we have technical difficulties. Every day there has to be technical difficulties."

Making Learning Comfortable

Mrs. Dawson firmly believes that students need to be comfortable in math class in order for learning to take place. She expressed her viewpoint:

> Because so many students have a problem with mathematics, especially in the regular classes, I think it's extremely important to make the child feel very comfortable from day one. 'This is a class where we learn; therefore, no question is too dumb of a question to ask.'

Mrs. Dawson does create an atmosphere where students appear to be comfortable when asking questions for clarification or offering comments. On one particular occasion, Suzie, a student from another class was sent to serve an "in-school suspension" in Mrs. Dawson's class:

"Hi, sweetie," welcomed Mrs. Dawson, as Suzie entered the classroom, "What are you supposed to do?"

"I'm supposed to stay in here," Suzie reluctantly answered.

"See, I told you – this is the best place to be. It's just like home," Mrs. Dawson encouraged. Asking some students in the centre of the class to change desks to make room for Suzie, Mrs. Dawson said, "O.K. Come and sit here so you can hear better and see better. You know what, Suzie? This is your lucky day because you're going to learn some math while you're serving time here."

"Nooo," groaned Suzie, "I don't pay attention to math."

"Oh, you will here. It's exciting stuff!"

As the lesson progressed, Mrs. Dawson demonstrated some triangles with *Fred*. As she manipulated *Fred* into a triangle with an obtuse angle that was practically straight, Suzie muttered, "That's not a triangle!"

"See, I told you that you would get involved," responded Mrs. Dawson with a smile in her voice.

Meeting Individual Needs

Mrs. Dawson was emphatic that her students are her first priority. This claim is apparent in her approach to individual help:

> My policy in my classroom is 'Ask for help any time, every time - and just tell me when you're coming and I'll be there for you - provided I don't have to be on supervision,' and make the students comfortable so that they can come for help any time they need to. And, so, it's just an on-demand basis and I'm always there for the students if they need the help or to go over their tests or whatever and I think that works really well that way.

She told us, "Many lunch hours are spent here with lunches," and added whimsically, "It would be nice if they bought me lunch too, but ... they don't."

Her dedication is acknowledged, however, in student comments such as, "She offers help before school, lunch and after school and also helps us in class," "She takes extra time to help," and "She simplifies the work, goes over homework, helps people in need." Parents, too, showed appreciation for the time Mrs. Dawson offers by writing, "She provides an environment for learning, facilitates good learning and helps when asked," and "She offers one-on-one help before and after school and at lunch."

As soon as her lesson is taught and students have some work to do, she gives students help during class by having the students "take a number" so that they do not have to line up at her desk. In this way, she tries to give each student a few minutes to ask about concerns from that day or the day before. She impresses on her students the importance of coming for help "right away" when they are experiencing difficulty.

In facilitating student needs, Mrs. Dawson was adamant about the need to "teach to their level." She likened it to an entertainer pleasing the crowd:

> It's like entertaining, when you're on a stage. Teach to the crowd, so if the students aren't understanding, you have to do it a different way. It's very important, if you're doing notes or exercises or worksheets or anything, that it's very clear, very distinct, very large, and that you talk slowly to these children so that they can follow you, and very clear notes. When I do give notes to kids, I tend to give them clouds or notes in geometric figures, and I have them highlight so it's color-coded, so that when they're studying or when they have to look something up, they can relate that definition to the blue cloud or the yellow cloud. These kinds of things give them little hints.

For example, at the end of a lesson that introduced formulas for finding volumes of prisms:

> Mrs. Dawson held up a sheet with diagrams and formulas that she had given the students and indicated: "This page is all your notes. I'd like you to take your highlighters and highlight – so that this jumps out at you when you are studying." Without breaking her cadence, Mrs. Dawson accommodated a few unprepared

students by going to her desk and tossing out a few highlighters. While pointing to each picture and formula on the sheet, Mrs. Dawson further instructed, "Highlight square pyramid and the formula, rectangular pyramid and the formula, triangular pyramid and the formula...."

Mrs. Dawson's students attest to her efforts in the following comments on what she does to help them learn math:

"Answers questions, explains slowly,"
"Helps one on one, and has examples on the board,"
"Explains things – gives me work when I ask or need it,"
"She gives us help when we ask."

Story-playing with Math

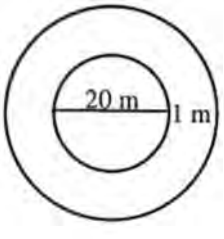
Another aspect of math learning about which Mrs. Dawson is passionate is the need to make it fun. One of her strategies for this is to make up stories:

> I try to attach a story to everything I teach. It's a little tough sometimes with negative exponents, but I've even found one for that. So, for instance, if you're teaching geometry, perimeter, area, ratios or whatever, put those students in that experience. You may say, 'Okay, David's taking out Hortence tonight and the ratio of their heights is two to one, and let's double-date and now we're going to put in another couple and their ratio is three to two'; and when you put the kid's names into the stories and you make it exciting, they will relate to that. So, years later, I will have kids coming back to me that are in university and they will say, 'Oh, hi Mrs. Dawson. Oh, I remember Hortence and Gertrude and Aloysius and Igor that you used to talk about in math class.' You know, they remember fun things, so you make it funny. Try to make it humorous sometimes and put a story behind it. The kids will respond and understand it better.

For instance, Mrs. Dawson spontaneously invented this story that included students when introducing a problem involving the area of a composite figure:

> "We're going to go to, let's see now," Mrs. Dawson began, "Gordon's backyard, and in Gordon's backyard he has built for his wife, Hortence, a nice big swimming pool, right?" This brings giggling from the class, as she draws a circle on the board. Mrs. Dawson continued, "The diameter of this swimming pool is 20 m. So Hortence says, 'Gordon honey,' ... you see now, they're having kids. Now the kids go out in the backyard and you have to watch little kids. So, Hortence says, 'Gordon, honey, I think we have to put a one metre sidewalk around the pool.'"

Mrs. Dawson completed the diagram on the board.



Picking up the story again, Mrs. Dawson said, "So Gordon has to go and do it himself because they don't have money to hire someone."

To keep a few wandering minds focused, Mrs. Dawson warned, "Listen to the story, there's a moral here."

"Gordon is going to buy concrete for this sidewalk, so he does; he figures that all out and then Hortence says, because this will make him grey, 'Gordon honey, you've got to paint that sidewalk.' "

"Paint it?" questioned one of Mrs. Dawson's students.

Without hesitating, she continues, "So he's got to go to the store. Look at the mathematics involved. He's got to figure out how much area the sidewalk is going to cover, right? ... because he's got to go to the paint store, and say, (in an exaggerated drawl that created a bit of laughter), 'Duh, I want 20 L of paint.' I don't think so. He's going to have to figure out how much paint he needs. So, how are you going to figure out how much paint you need? Well, on the paint can, it usually says one litre covers one hundred square metres – or something like that. So first of all he's going to figure out how many square metres – you see where the math comes from? You see, you use math every day, all the time. Here's one example."

Asking for suggestions, hands go up, and David, being recognized by Mrs. Dawson, suggested, "Figure out the area of the small circle and the big circle."

"OK, stop right there," Mrs. Dawson interjected, and then proceeded to develop, with the students, a formal compound area formula, including subscripts ($A = \pi r_1^2 - \pi r_2^2$).

She reinforced the need to find the difference by saying, "You subtract it, you don't want to add them, because what if Hortence comes out and there's Gordon painting the water? Then she'd be putting him away pretty quick. You don't want that, right?"

"So, big circle take away little circle, I call this my doughnut problem because it looks like a doughnut. You see a lot of these, it's extremely popular."

"Go ahead, take out your scientific calculators, punch in the numbers and give me an answer." After allowing some time, she asked if anyone has an answer.

David replied with his answer of 65.94 m^2 and then she asked, "Everybody agree?"

Hearing no objections to David's response, she added, "That sound's about right."

Developing Every Student's Potential

Reflecting on her many years of experience, Mrs. Dawson expressed strongly her belief that students should be grouped so that they are among their intellectual peers:

> Especially in math, where there's a huge disparity from an extremely low student to an extremely high student, where the teacher has to be teaching to the middle, I think those students who are at both ends are at a huge disadvantage as soon as they walk in the door. The high, because if you're not challenged, if you don't progress, you regress. ... If you're not with your intellectual peers, it's like anything else, you will meet the level you're at – like water. That student has nothing given to him over the year – It's a wasted year. On the other hand, if that slow student walks in the door, they haven't got a chance because the teacher will be teaching to the middle. ... If you set up math classes where students are at the same level, it's a huge advantage to teacher and student. The teacher can teach to the level of the student, the student can feel successful and even though they're low, they can see themselves as being average in class, or even emerge as a leader – a terrific self-esteem booster.

While her school does not currently do any streaming in the regular (non-AC) classes, Mrs. Dawson is a firm supporter of the AC program:

> I think when you say, 'Why are you successful?,' it's because we have situations like that here. We have students with their intellectual peers and they will try to meet the level of that student above them; and they just get better and better and better, because they want to be better, because they can see the next guy's better. And they're all very much at the same level.

Professional Development

Professional development has high priority in Alan Lane School. As well as receiving a yearly professional development allowance of $350, each teacher may use student teacher money in this respect; and there is also money for consultant services and inservice sessions. The school applied for, and was chosen to participate in a district initiative to improve student achievement. By extending the school day slightly, five more professional development days were made available, in addition to the two already allowed by the school district. This decision was made after the principal consulted with staff, students, and parents through the school council: "We ran several proposals past them, and I think they came to the conclusion that better teachers improve student learning – teachers make the difference! And if we can have better teachers, then we're going to have better student achievement."

The plan allows teachers more time to plan for the students. They have more time to do report cards, which is significant, because according to Mrs. Dawson: "We have very extensive report cards in this school. I believe they are about 12 pages long." She also commented that there is more time for meetings, "But during the day we can at least get together and have a good meeting – is what I like. Because you can't do it after school; people have to leave for certain reasons. You can't do it at noon because people have supervision, and there's the bell! So, at least we can have a good meeting and discuss things." Students may also benefit from the plan by using these extra PD days to study for exams or make medical appointments without missing school.

The Value of Collaboration

In Alan Lane School, collaboration among administrators, teachers, and students and teachers is evident. Mr. Albright was very enthusiastic about his staff, which he considers to be the school's greatest asset. He elaborated:

> They all care about kids. They're an excellent staff! ... They're very supportive of the changes that have happened over the last three and a half years. They've made it easy for me. They've been really strong. They're a dedicated, hard-working staff. I love working with them. I'm very grateful. Every day, I count my blessings!

Indicating the effect of mutual support, Mr. Albright said:

> We're pretty focused on the academics and I know Mrs. Dawson has appreciated the support; once the school's running well, she can teach well. She's been supportive of me and I've always been supportive – I've been supportive of everybody. I try to work with each individual teacher, so those are things that I think we're doing well."

He is there for his staff with respect to student discipline: "Yeah, I'm pretty firm there. I support them to the hilt ... The kids know where they stand with me. They know when they mess up they're going to be dealt with and their parents will be contacted."

Sharing Expertise

All the math teachers in the school work together cooperatively, sharing their expertise. Mrs. Dawson spoke of this teamwork as another factor in her school's success in mathematics: "We are also able, because of our experiences and knowledge, to collaborate and share ideas and share units and share worksheets and teaching ideas, etcetera, etcetera." She especially stressed the sharing:

> Not only are we sharing pieces of paper, but we are sharing ideas - and how to teach - and what to teach - and the different ways of teaching - and it's different communicating with a person whose main interest is in that department (mathematics) rather than communicating with a person whose main interest is let's say, music or phys ed, and math is just a periphery subject.

As the Mathematics Department Head, Mrs. Dawson finds it difficult to hold formal math department meetings because of other demands on teachers' time. She explained how "Everybody is on supervision or they're in a meeting with somebody else – or they have to leave for personal commitments. So, whenever we have math meetings, it's more or less for information from myself." Meetings are held for things that are considered "crucial" such as exams; otherwise, most departmental communication is effected through memos and informal meetings: "We collaborate on a daily basis" at noon hour, morning, during a prep and on the run!"

Mrs. Dawson's classroom shelves bear a wealth of math resources which she has acquired over her twenty-six years of teaching, and shares freely with her colleagues. Pointing across the room, she indicated:

> See that shelf over there – right above that box, O.K., all those little books there? That's full of math problems and different kinds of activities that I've collected, and all the teachers know they're there; and a lot of the teachers just walk in and help themselves, even when I'm teaching. I like to have that comfortable atmosphere where they can share anything at any time. We do that a lot.

As a member of the Mathematics Council of the ATA, Mrs. Dawson regularly attends math conferences, and reads professional journals. She shares ideas gleaned from these sources with the other math teachers.

Links Between Elementary and Junior High

There is also dialogue with the elementary teachers in the school. They may ask Mrs. Dawson for help and share ideas. In the past, when teaching some elementary AC pull-out classes, one of Mrs. Dawson's main focuses was preparing Grade 4, 5 and 6 students for elementary math contests. The principal expressed enthusiasm about elementary-junior high teamwork:

> We've had more interaction between our junior high and elementary this year than in the last three years and I really encourage those cross-overs – whether it be junior highs are running turkey trots in the fall, or they're doing paired reading programs with the kids or writing stories and doing storybooks with the kids. It's just tremendous some of the stuff they're doing and I really encourage that, and the teachers have really caught on to that, too. Another thing – I've had more junior highs this year working with the elementary teachers, giving them relief, even if it's in phys ed or in French; and so, there's just more dialogue between the two different parts of the school.

Community Support

The changes in the school in the past four years have been very well received by the community. For Mr. Albright, evidence of this is the number of parents who wish to enroll their children: "That's probably my biggest indicator, is when they're lined up at the door, we're doing something right." Admittance is based on criteria set by the school board and which is "followed to the T." Parents are visible in the school, and the principal values their support:

> There's probably 5 or 6 parents in here volunteering today. I try to make the parents feel welcome. I think it's really important to have the parents here in the school, seeing what's going on. You know, we're fortunate – a number of parents here don't have to work, so they can come in and work, and it works out pretty well – It works out very well!

Parents were asked what factors they believed affected their child's success in mathematics. Some responses focused on the role of the teacher. For example: "A good teacher, a well structured program, review questions," "Teacher-student relationship, " "The teacher, " "Good instruction," "A teacher who is enthusiastic with all learners." Some parents acknowledged their child's role in comments like: "Doing his homework,"

"Math confidence," "Attitude and completing all assignments," "Lack of organization and interest."

Continuing the Quest for Excellence

Alan Lane School's ongoing mission towards student success is evident through its focus on excellence, dedication to good teaching practices, and the generous collaborative spirit shared by all stakeholders. One parent's comment indicated that success is a team effort:

> A stable family environment that supports learning and values it. With this basis the child, along with a good environment in school, with supportive and good teachers, creates success. The principal sets the school atmosphere for a well disciplined school. He interacts with teachers and removes garbage that gets in the way of learning. This atmosphere and attitude sets the focus for the teacher and students to work.

Alan Lane Elementary/Junior High School

Kathy McCabe

Mr. Albert

"Students need to be successful right off the bat so I try to find ways to make them feel success."

As Mr. Albert notes, success is a focus for the school, his class and all students. Students attending Alan Lane school are expected to perform well and in most cases they do. There is a history of excellence in this school community and this is the focus in all areas including athletics, the arts, and the academics.

The Teacher: A Concerned Motivator

Mr. Albert has been teaching for five years, but this is his first year in this school. He has neither a major nor minor in mathematics, but said he enjoys teaching it and participates in workshops and conferences. He said he transferred to this school to have an opportunity to work with Mrs. Dawson, the mathematics department head. He is currently teaching grade 7, 8, and 9 math and an elementary physical education class. Mr. Albert is obviously well liked by his students who greeted him as we walked down the hallway. A couple of students asked him how they did on the previous day's test. He told them he couldn't remember exactly what they got but they did well. He told me that he is very proud of that class because they all did so well on the exam.

Mr. Albert cares about his students' progress and monitors it carefully. He frequently calls home to let parents know about their child's progress. He said this practice is strongly encouraged by the administration. Several parents responded to the question of "what the teacher does to make their child successful" by stating that he constantly keeps them informed about his/her progress. Mr. Albert related a story about one student who was really struggling. He said he phoned the boy's dad a few times because the student was currently living with the father. He said he felt he was getting nowhere, so he phoned the student's mother. The mother was very concerned and said she would try to help out. Mr. Albert now says the student is, "Doing awesome." He then notes that awesome for this student is 55%.

The teacher treats the students with respect and always responds to them in a positive manner. If he asks students a question and they get it correct, he usually says, "excellent" or "good job."

Another ten minutes passed and the students were still working quietly, most on the review assignment, a few on the contest.

Mr. Albert circulated around the room offering such comments as: "This is the right idea, right?" "You got it!" Finally Mr. Albert took a seat at his desk, and students went to him for help.

Mr. Albert believes in challenging his students, especially those in the academic challenge class. The questions from one review package he gave the class were quite

difficult and pushed the curriculum. There were several questions that involved the use of two right triangles. This is an outcome from a common cluster in the grade ten program. Because this is an academic challenge class it appears that they are expected to be able to extend their thinking to this type of question.

Helping Students Learn Mathematics with Explanations

In their questionnaires, many of the students indicated that one of the ways Mr. Albert helps them learn mathematics is by giving clear notes and lots of examples. The students also note that he is always willing to help and is available before school, at lunch and after school.

The teacher handed out graph paper and told the students to take two sheets each. "You're going to have to draw some shapes on your sheets. One sheet is for your notes, one is for your homework."

"Is it a new unit?" a student asked.

"Yes it is. It's on transformations."

The teacher instructed the students to put the notes in their regular notebooks and to put the graph sheet with the diagrams right behind it so they would know which diagram goes with which part of the notes.

"Can anyone tell me what a translation is from last year?" the teacher asked.

The students did not respond.

"Okay, a slide is one. What happens with a slide? Can it turn around?"

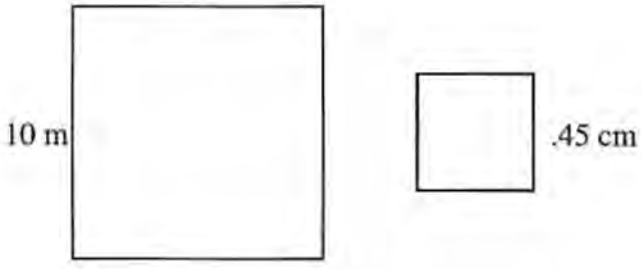
A number of students gave the correct response and Mr. Albert went on to other translations. When doing so, he often used his body to demonstrate the translation—embodying the geometry of position and motion. For example, he asked what type of translation his body would have gone through if he were to walk up a flight of stairs or what translation would be represented if he lay down.

For 20 minutes Mr. Albert went through explaining three types of notations for translations. While doing so, he frequently checked for understanding by asking students questions. Recognizing that one student had trouble understanding Mr. Albert re-explained the concept. His tone remained positive when he explained new concepts. He later commented to me that students need to have a positive attitude towards math and he modeled this by saying, "Let's try some more here and then you will get it."

Once finished the lesson, Mr. Albert assigned homework—41 questions from the text book. Most of the students started on the homework, but noticing that one student had not begun, Mr. Albert approached the student and asked why he hadn't started. The student replied that he didn't get it. Instead of making an issue of the student's comment, Mr. Albert simply told the student to come in at lunch and he'd give him a hand.

A couple parents suggested that Mr. Albert tries to explain things in several different ways and this helps their children learn. "[Mr. Albert] explains again or tries explaining a different way or tries to find out what the child knows already."

The teacher had the students look over their worksheets and then asked if there were any questions. At this point one student asked a question. The teacher put the information and diagram on the board. He was careful to include all measurements and units. Instead of just doing the question, Mr. Albert asked the student how he thought he should start and what information was needed. The student was unable to tackle the problem so the teacher posed an alternative, slightly easier question to the student.



The teacher asked the student what operation should be used to calculate the number of small squares required to fill the large square. The student incorrectly said the operation was subtraction. Wanting the student to recognize this was a division problem, the teacher asked, "If I have x number of candies how many will each kid in class get? How do I figure this out?" The student correctly answered that you will divide. The teacher then connected this solution to the original question and the student correctly deduced that the operation was also division. There were no further questions so the teacher instructed the students to pass their assignments to the front of the class and he would record the marks later.

Well-Managed Classroom

When students are in Mr. Albert's classroom they are there to learn. He does not allow them to horse around; he expects them to be on task at all times. Any work that is not completed in class he expects them to do for homework. Of the 25 student questionnaires the majority of students, 13, said they do math homework 5 or more nights per week. Most students reported spending a half-hour or more on this homework.

From observing Mr. Albert's classroom, it is obvious that he is concerned that the students learn the material and he is there to ensure that they do. As one parent stated "[Mr. Albert] tries to keep [my son] on track and lets us know if he is not working hard or is not doing his assignments." Mr. Albert is a fairly strict disciplinarian but he does it in a quiet manner. The atmosphere of the class was very pleasant, the students seemed to be

generally well behaved but also relaxed. In the classes I observed they got down to work right away and asked very few questions. Misbehavior was not tolerated. One student who was goofing off was quietly told to leave. In another class, a student who did not respond to Mr. Albert's request to get on task was told to come in at lunch. It is clear that by handling small disruptions Mr. Albert manages to maintain a well-ordered classroom. The next illustration demonstrates how the routines of this classroom are well established and facilitate learning.

The first class observed was a review class which included no instruction of new material. The first 20 minutes of class were spent marking a test and for the remaining time in class the students worked on an assignment from the text.

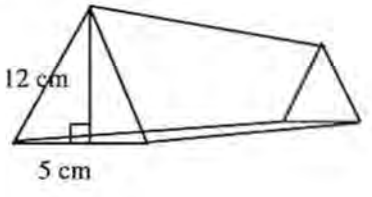
The students seemed to know the routine and quietly helped each other or asked Mr. Albert for help as he wandered around the room. One student asked, "Which side is the hypotenuse?" Another asked a question about the Pythagorean Theorem. Mr. Albert seldom answered the students directly but tried to draw the answer out of them. Mr. Albert insisted that the students show their work not just the solutions. He said this is particularly important when students are working out of the textbook as the solutions are in the back.

I had previously asked Mr. Albert if the students used calculators and he said about half did but that he really doesn't emphasize their use and usually tries to make test questions that don't require the use of calculators. On this day it appeared virtually all students were using calculators.

It is interesting to note that even as the students helped each other, they included the units when they talked about measurements. Generally, too, the students used correct mathematical terminology. I overheard two students in conversation, "Nope, the two triangles are congruent." "Is this one supposed to be a triangular prism?"

The students appeared to know what was happening and were content to get down to work. The students seemed to be motivated and in most cases were happy to work on their own.

Twenty minutes passed since the students were assigned the work and they were still working quietly as the teacher wandered the room. In response to a student's question Mr. Albert went to the board to solve a problem involving the surface area of a triangular prism.



The students worked quietly for another five minutes before the noise level started to go up. Somewhat distracted a student asked if they still had to do section 7.5. Mr. Albert responded that if it was quiet now they wouldn't have to. There was some talking going on but obviously Mr. Albert must have felt the class worked hard enough so just before the students left he went to the board and erased 7.5, the last part of the assignment.

Managing the Mathematics

Mr. Albert placed the key to the assignment on the overhead. He told the students the questions were worth three marks each. He instructed the students that one mark was for the diagram, one mark for the expression and one mark for the solution. In response to a student's question, Mr. Albert said that if the diagram is wrong the whole thing is wrong. He also told them that they may use a different trigonometric function to get the same solution and that is fine. He continued to place the solutions on the overhead and the students marked their own papers.

As the students marked their papers Mr. Albert mentioned that maybe instead of just drawing triangles, drawing figures and shapes may help them do the questions. A student asked the teacher if she could get some marks on a question because she wanted to use an angle other than the one given and had incorrectly found the complementary angle to 12" to be 88", Mr. Albert responded, "No marks."

Mr. Albert insisted that the students use correct mathematical notation and language. He expected the students to show all the necessary steps and awarded marks in such a way that this was emphasized.

Mr. Albert also told me that at the start of the year he will mark a question wrong if the student forgets to include the correct units. From the observations I saw a similarity between how this teacher manages his classroom and manages mathematics. That is, procedures are to be done in a certain way, answers take a specific form and although Mr. Albert acknowledges that there is more than one way to do a question, it is the answer that matters.

In another class Mr. Albert put examples on the board quizzing students on how to find areas of composite figures. He again reminded them to be sure they use the correct units. One student asked if they have to write the units all the way through the computations. Mr. Albert said if it helps you remember to put them in at the end, yes, otherwise no you don't have to. When finished with the board work the teacher gave the students an assignment and told them they should have no trouble with it as it was nothing new to them.

The School: Collegial Atmosphere

I believe part of the reason this school is successful is in the attitude of all the staff. They expect the students to do well and achievement is acknowledged. The expectation of excellence permeates through the entire school community. Teachers

speak with pride when discussing the students' accomplishments. The staff seems very cohesive and very supportive of its administration. Mr. Albert mentioned many times the help he receives from Mrs. Dawson. A couple parents, on their questionnaires, mentioned that their child had an excellent teacher in the previous grades. When asked what the teacher does to help her child in mathematics one parent noted, "Grade 7 and 8 teacher was superb. She challenged them. Sometimes I believe kids are bored stupid- [the grade 7 and 8] teacher had them do fun exercises."

Mr. Albert uses a variety of tools in his classroom. The main text the students use is *Math Power* but he says he likes to use *Interactions* for the better students. He believes the variety of questions in *Interactions* allows the students to realize that not all problems are the same and you always have to look for different ways to solve these questions. He says he finds he has lots of time in the program so he uses a lot of supplemental material. He mentions that he works very closely with Mrs. Dawson. Often she will make the extra assignments and tests and he will word process them for her. Mrs. Dawson has binders full of additional materials in her classroom and she is willing to share them with Mr. Albert.

This sharing atmosphere has led to a strong department and, I believe, this strength has created success in all grades and is, then, reflected in the success of the students on the grade nine achievement exam. Success in one year is often based on a strong background from previous years. As a couple parents noted, their children were doing well in grade nine because they had had an excellent grade 7 and 8 teacher.

Currently there are two teachers teaching grade nine math, Mrs. Dawson and Mr. Albert. Mrs. Dawson acts very much as a mentor to the less experienced Mr. Albert. Mr. Albert is willing to learn from others. He mentioned to me that he did not know how to change numbers from base ten to other bases so he sat in on Mrs. Dawson's grade seven class and learned it along with the students. Mr. Albert is obviously willing to learn from his peers. I believe this collegial atmosphere is one of the reasons the students are successful. The teachers learn from each other and pass this attitude along to the students. Mr. Albert's respect for Mrs. Dawson as an authority is reflected in this exchange I observed in his class.

> *The first questions on the review were very straight forward and students had no questions. Most of the questions were of the form: tan 25 " 3200/x.*
>
> *When some of the students questioned the rounding in his solutions, because they were off by one or two units , Mr. Albert said, "What's happening in these questions is Mrs. Dawson does it this way:"*
>
> $$\tan 25 = 3200/x$$
>
> $$.466 = 3200/x$$
>
> $$x = 6866.95$$
>
> *"When we do them we divide by the whole tan 25. That's why there's a difference. Ours is more exact."*

The Students: Independent Learners

> *On this day, as in the previous class, the students settled down immediately upon entering the classroom. This class began with Mr. Albert handing out certificates for the students who achieved in the top 25% of the Pascal contest. Ten students achieved this standard and were called to the front of the room to receive their certificates. The rest of the students applauded. After congratulations were extended Mr. Albert handed back the project from the previous three class days.*

There is a real emphasis on success in Alan Lane School and students perpetuate this focus as much as their teachers and parents do.

Many of the students choose to come here for the academic challenge classes. The school has a reputation of excellent results so even students who would not qualify for the academic challenge classes come here with expectations of success. The students appear to be independent learners for the most part. They are on task when in class and do the work expected of them. The classes appear to have clearly defined rules and the students are comfortable with the roles expected of them.

> *I sat in and watched Mr. Albert's grade nine academic challenge class. As soon as the bell went, Mr. Albert handed out assignments, placing them on empty desks. As the students arrived they immediately started to work on these worksheets. There was absolutely no downtime. Mr. Albert told the students there was a contest for them to work on when they finished this set of review sheets.*
>
> *I learned from Mr. Albert that this class is a whole unit behind his regular grade nine class because they spent a month on equations and inequalities. He noted that he finds he has lots of time in the program and supplements a fair bit. He again mentions that Mrs. Dawson has many resources they use to enhance the program.*
>
> *On this particular day the review assignment was like a quiz in that it could not be taken home and the students worked on it alone. They were encouraged, though, to consult any resources for help. Mr. Albert noted that the assignment consisted of fairly hard questions and said he does help the students if they really need it. One student asked for help and Mr. Albert told him to draw the building stating "It really helps if you draw a picture."*
>
> *Mr. Albert said he requires the students to draw diagrams in the trigonometry unit as he believes the visuals help them to understand the problems.*
>
> *Ten minutes later the 22 students in class were still hard at work as the teacher circulated throughout the room. As he helped students Mr. Albert occasionally demonstrated with his body what the shape would look like, "If my arm is bent here it's like the pole in the problem." After getting all the students' attention Mr. Albert said, "In question 20 the flag pole is on the top of the building. Sorry that's kind of unclear."*

Twenty minutes later some students finished the review package. They quietly handed it in and picked up a practice contest and began to work on it. The students are usually given a half hour on their own to work on the contests and then they go to small groups to compare solutions. All academic challenge students work on these contests. Because of the difficulty level of the questions the grade nine students get one mark for each question so their contest is recorded out of 12. It is recorded out of 10 for the grade eights and out of 8 for the grade sevens.

The students seem to like working on their own and like to be challenged. Mr. Albert observes that this group of students are "very **me** oriented; they really only care about themselves." Because of this he mentions that he does not do a lot of group work with them. In fact as he did his examples, only a few of the students copied directly from the board. The rest appeared to be doing the questions on their own. The students seemed confident in their own abilities and seemed to like to work things out for themselves. When the students were doing seat work most chose to work alone but some worked in small groups. Mr. Albert did not discourage this and the group seemed to be able to answer questions from each other.

The students take advantage of extra learning opportunities afforded them. Mr. Albert mentions that even the grade eights love to play Crypto, a math card game, if they are finished their work early. The students will seek extra help outside of class time if they feel they are having trouble, as mentioned by several parents in their questionnaires. The grade nines will happily do extra contest problems if they have the time after their class work is complete.

Just before the students left for their next class Mr. Albert talked about what needed to be known for the test. He told the students that, "The test is plain and simple like the questions from the text." Mr. Albert handed out the contest questions to the students who hadn't yet picked them up. Mr. Albert commented that the contest questions count for only about 5% of the student's mark but that these students are so mark conscious they will do them. He told the students to hand in their review packages but if they were not done they could finish at lunch today or Tuesday. Mr. Albert later told me that he would usually let the students finish after school if they liked but he wouldn't be there today.

Summary

There may be several reasons why students in Alan Lane School achieve well on the grade nine achievement test but I believe the reason that has the greatest impact is that they expect to do well. The high expectation of student performance seems to be a self-fulfilling prophecy. Great results are expected by parents, teachers and the students themselves.

Most of the parents who responded to my survey indicated that one, or more often both, of the parents had some education beyond high school. This indicates, to me, that these families are likely to place a high value on education and pass this on to their children. Most of these families have also lived in the neighborhood for quite a while so

one might expect that they like the area and that their neighbors hold similar values to them.

The staff at Alan Lane also expect their students to do well. Great emphasis is put on celebrating success. One might assume that competitiveness is also encouraged by the number of contests the students enter. The teachers mentioned to me that though not all their students are AC they still manage to achieve higher school scores on many of the math competitions than the schools who have only academic challenge classes. The staff will also work with students to ensure their success. Even the principal will offer tutorial classes at noon hour for students whose marks are not up to standard.

Because of the influence of their parents and their teachers, many of the students in Alan Lane believe that they have to do well in school in order to be a success in life. With this view in mind, the students take their education seriously and work hard to achieve. The teachers are constantly in touch with the parents so student progress is always being closely monitored. Most of the students I observed seemed to be able to work well on their own but would seek help when needed. The students also appeared to like the challenge of mathematics, often choosing to solve a problem on their own rather than wait for the teacher to do it. They seemed to want to please their parents and teachers but they also seemed to be intrinsically motivated to do well. I believe this to be the single most important factor in the achievement by the students in this school; the students want to, and believe they can, do well.

Five

Gilhooly Junior/Senior High School

Shannon Sookochoff

Mr. Wilchuk

I spent three days in Gilhooly, Alberta observing the teaching of Bill Wilchuk. There, I saw some of the most incredible mathematical conversation I have ever seen. As well, I came to understand the pedagogical significance of "taking note." And, I grew to appreciate the enormous impact that a community can have on the learning of mathematics.

Part 1: Talking about ways to calculate the area of a regular polygon

Students in Bill Wilchuk's class appreciate the way he begins class by "talking." One student said, "We talk about something different everyday. He asks the class to give answers.... It makes me listen more." Mr. Wilchuk credits this kind of relaxed conversation to the extra time that he gets to teach math---the school schedules more time for core subjects than is mandated by Alberta Education. He says that before he had the extra time, he used to take up homework at the beginning of class. But now that he has more time, he chooses to begin each class with something new.

The following is a transcript of one of the mathematics conversations that I observed in Bill Wilchuk's class. The conversation lasted 14 minutes. The "new" concept for this particular class involved calculating the area of regular polygons.

"Okay, if I can have your attention so that we can get going." Mr. Wilchuk stands near the front of the room, introduces me and reminds students of a drama workshop that will be held that evening.

"The sheet I need you to find is this one." He turns on the overhead. "If you find yesterday's worksheet, today's sheet is on the back of that." He pauses while students get out the page. "Anybody not find that one?" The overhead/ handout is one that Mr. Wilchuk has generated himself (see Figure 1). He refers to it as "notes" and dates it on the top right corner. His students do the same. "Okay, the last couple of periods we did a very quick review of shapes that you've already covered from the past. I'd like to get into something a little new. I'd like to get into regular polygons, the word regular implying all sides and angles are the same, if you wish. Believe it or not, there are ways of finding areas of shapes like this. That's where we're headed."

Mr. Wilchuk lets the students know where they are "headed."

He continues, "Now the question I have up here says, 'find the perimeter and area.' Even though its says 'perimeter,' I'm only going to do the perimeter part once with you because I don't think that you as a class need to do a lot of them. So we'll take care of that in a hurry."

Mr. Wilchuk has confidence in students.

"The one thing that is new to you is the polygon's *apothem*. The apothem is the distance from the midpoint of any one side to the center of the polygon. So I drew it here." He points to the dotted line in the hexagon in Figure 1. "I could have gone from this side to the center, it doesn't matter, but that is called the apothem."

"Okay, let's proceed. The first shape: a regular hexagon. How about somebody telling me... how would I find perimeter? How would you do this?"

Students are responsible for thinking of methods and procedures.

Several students speak at once. Mr. Wilchuk chooses one.

"One of you mentioned 'add up all the sides.' I can do that." Then he adds, "I get some of you saying that you like to do things faster than that. What's your faster technique?"

Class climate invites student responses.

Again there are many answers at once, including "25 times 6" from a student at the back.

Another student offers, "Multiply the length of a side by the number of sides."

The handout frames the student notes. The notes are a brief record of the mathematical conversation.

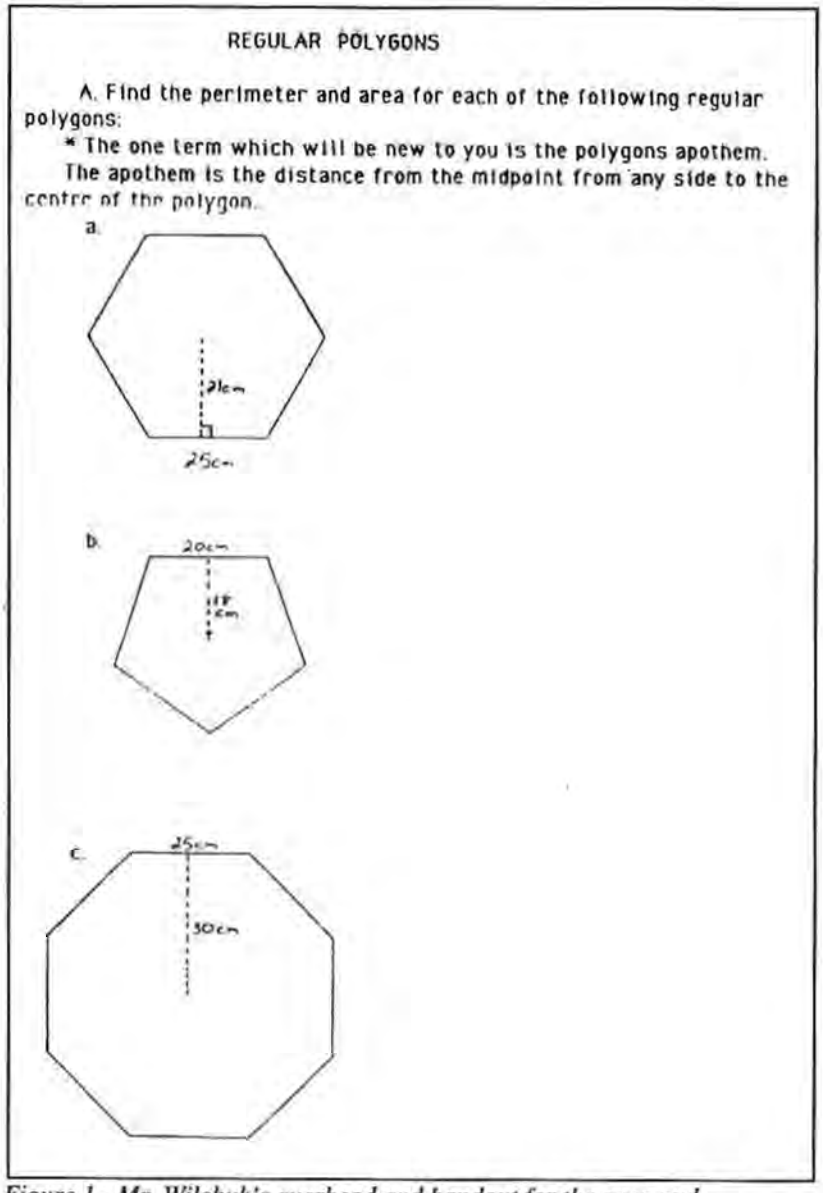

REGULAR POLYGONS
A. Find the perimeter and area for each of the following regular polygons:
* The one term which will be new to you is the polygons apothem.
The apothem is the distance from the midpoint from any side to the centre of the polygon.
a.
21cm
25cm
b.
20cm
c.
25cm
30cm

Figure 1 - Mr. Wilchuk's overhead and handout for the area and perimeter of a regular polygon

The teacher uses student names often and credits students with the ideas.

The teacher and students don't depend on text books and recipes.

"One at time, though. Lee Ann says 'why don't you just multiply instead?' And she's correct. So 6 times one of the sides would give us our answer right away, which in this case turns out to be 150 cm. Please remember that perimeter is a distance problem so your units must be linear."

"Okay, I imagine that some text books have formulas for this. We said that we don't need formulas for perimeter. But out of curiosity, can somebody here generate a formula for the perimeter of a six sided regular polygon?"
Mary contributes, "$P=a+b+c...$"

"Mary just said 'Why don't you just put $P=a+b+c+....$' That will work." There are more responses from the class including, "Just use $6s$."

The teacher is interested in his students' learning and thinking.

"Sure, a lot of text books, to write this quickly, would put down $P=6s$, meaning 6 times one of the side measures. And that will do it very nicely, for a regular hexagon. Now later on, if I asked you to find the distance around a regular pentagon, you'd change it. $P=5s$. Nonetheless, for perimeter we can just simply add up all the sides, we're not worried about that. I'm curious as to what you're going to do... for area."

Trevor blurts out, "Radius. The diameter."

The teacher uses a seemingly closed question to ask the students to explain the idea in more detail.

"Okay, careful Trevor. Radius refers to basically circles as a subject." Lots of students speak about Trevor's idea and contribute other possibilities.

"Only one at a time," Mr. Wilchuk reminds his class. Then he calls on Mike who suggests splitting the polygon into smaller shapes.

"Can you be more specific?"

Mike answers, "Two triangles and a rectangle."

A student sitting near Mike grasps the idea. "Oh, I see what he's saying."

The whole group owns the decision of whether Mike's method makes sense.

Mr. Wilchuk begins to sketch Mike's idea on the overhead. "I'm going to try to copy what he's indicating. I don't know if Mike wanted me to split it this way, but at least this is one way I could do it. Okay...." He sketches Mike's idea on the overhead. (See Figure 2) Then, before making an attempt to solve using Mike's method, Mr. Wilchuk asks the class, "Can we check to see whether or not his method will work?"

Andrew responds, "I think it will."

And there is a chorus of "It will."

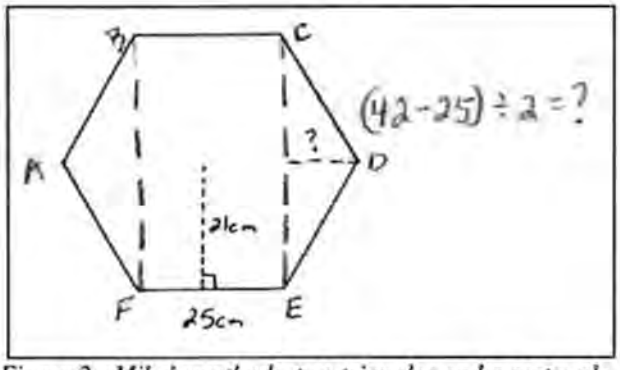


Figure 2 - Mike's method: two triangles and a rectangle

The teacher acknowledges involvement.

Mr. Wilchuk begins to calculate, "I can take 25 and I can multiply it by--"

He overhears a student say "42."

"Excellent," Mr. Wilchuk commends, "--42. That will give me the area of the rectangle. How about these triangles?"

Students feel confident in their contributions.

A student volunteers, "25 and 25." She is talking about the two short sides of the triangles in the sketch. (See Figure 2.)

The teacher works to understand student thinking.

"This is 25, that's 25...." Mr. Wilchuk confirms. "What's the distance from here to there? In other words the height of the triangles in Mike's method."

Mike calls out, "42 take away 25 divided by 2."

"Now you're going to have to slow down for us. Say that again?"

"42... take away 25... divided by 2."

Mr. Wilchuk thinks out loud, "42... take away 25..."

The teacher suspends the extra information that he has about the hexagon so that other ideas can be entertained. He also allows Mike to feel successful, like his idea is good, just too confusing for others.

With further explanation from Mike, Mr. Wilchuk finds out that Mike thinks that the distance from vertex A to vertex D is the same as twice the apothem. In this case, 42 centimeters. The clarifying takes about 45 seconds and several students get confused and begin to murmur.

Mr. Wilchuk does not correct Mike. Instead the teacher defers Mike's idea for a moment saying, "It may or may not work, but I'm with one of your colleagues here--it's sort of confusing. 'It hurts the head.' I'm not going to say right now that your method will not work, but I think that some of your fellow students are saying that it's a tough one."

The teacher's pause to consider Allen's idea gives students a chance to form an opinion themselves.

So, Mr. Wilchuk encourages more discussion. "Other suggestions, one at a time.... Okay, Allen."

Allen suggests dividing the hexagon into six triangles.

And Mr. Wilchuk wonders aloud, "Six triangles..."

Without being prompted students turn to their neighbors and chat about whether Allen's idea will work. Mr. Wilchuk begins to divide his hexagon into 6 triangles and listens to the student discussion.

The teacher knows that Allen's idea will lead to a solution, but chooses to explore the learning in yet a different idea before going back to Allen's.

The conversation continues for about 10 seconds until Dean says, "Stop right here!"

So Mr. Wilchuk interrupts the class discussion, "Hold it. Allen said '6 triangles' and in my attempt to start to divide it, Dean said 'Stop right here!' So, Allen, I'm just going to put you on hold for a second...."

Students giggle at the idea of Allen being put on hold.

"Now, Dean is suggesting that this will work." Based on Dean's suggestion, Mr. Wilchuk divides the hexagon in half making two trapezoids. (See Figure 3.)

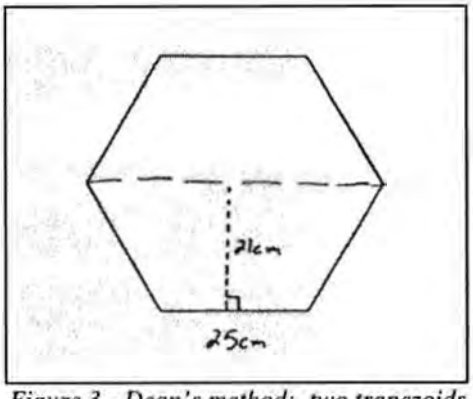


Figure 3 - Dean's method: two trapezoids

The teacher sees that Dean's idea offers students an opportunity to review what they know about trapezoid.

"Do you know how to find the area of a trapezoid?"

Several students answer, "Ya."

So the teacher continues, "So I could find the area of one, double it, and I've got the area of this thing. Now, do I have all my numbers? Do I know this distance?" He points to the base of the trapezoid and the distance that Mike had earlier thought was 42 cm.

"42," offers someone.

"It's not 42," says Mr. Wilchuk.

The teacher allows students some time to think out loud.

"45," suggests Cynthia.

And Jeff echoes "45."

"46?"

Then "Uh-oh."

And another "Uh-oh."

And "Uh-oh."

Mr. Wilchuk interrupts the confusion. "Actually, Dean the neat thing about a hexagon is that it is made up of 6 equilateral triangles. Or regular triangles. And,

The teacher chooses this moment to add the new information. He has a sound background in mathematics to draw from.

if this is 25," pointing to the side of the hexagon, "this side must be 25, from here to here." He gestures toward the distance from a vertex to the center of the hexagon. "Believe it or not, I could find the base of this trapezoid."

"50," someone shouts.

"That is 50," Mr. Wilchuk confirms. Then he goes back to the original question: "Do I have all my numbers?" And discovering that indeed he does, he proclaims "Hey, I can do this!"

The teacher "discovers" and shares his joy with the students.

A student wrinkles her nose.

"Okay, you may not like this method," Mr. Wilchuk says to the student, "but, nonetheless, I can do what Dean suggested.... Dean, can I get you to focus on this shape?" Mr. Wilchuk indicates the pentagon on the overhead. "Does your method still work when I change the shape?"

Even though they have an appropriate method, students still do not "calculate" area. This conversation is not about a numerical answer.

"No," several students conclude.

"Okay, so even though his procedure will work for one, it's not universal in that it will not work for all the regular polygons. Now, Mike's method. He's maybe saying, 'you didn't give my method a chance.' His method may have worked had I gone through it completely with him. Would his method work down here with the pentagon?"

The teacher affirms "Mike's method."

"Yes," says Mike.

Mr. Wilchuk questions, "You can break it up into a rectangle and two triangles?" With that, Mike agrees that his procedure would not work for the pentagon and plays at looking deflated.

Allen laughs. So does Mr. Wilchuk.

Students enjoy the process of proposing and refuting ideas.

"Okay Allen, going back to yours." Then he teases, " We'll criticize yours in a minute. So, we'll see."

Other laugh, anticipating that Allen may be proven wrong.

"There's nothing wrong with it," Allen asserts, smiling.

"He says 'nothing's wrong with it.' Well, we'll see. You'll have to excuse my rough drawings here but I'm supposed to have six regular triangles. Before you draw, we better make sure that everybody's comfortable with this material. Okay Allen, would you explain your procedure."

The teacher puts Allen into the role of mathematician.

Allen explains, "Kay, you divide the hexagon into six triangles and use the area of a triangle formula to calculate the area of each triangle. Then, you multiply by 6." (See Figure 4.)

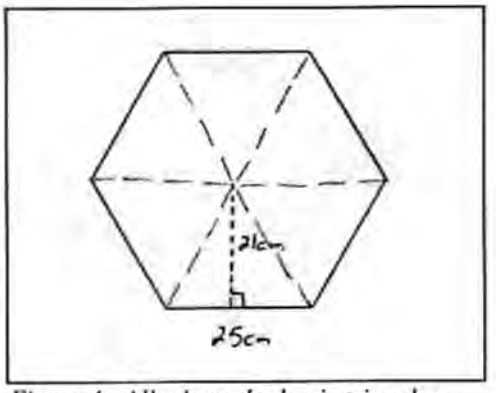


Figure 4 - Allen's method: six triangles

Mr. Wilchuk asks Allen, "Dean's method worked for the first question. Is your method going to work for this guy, the pentagon?"

"Nope." Allen quickly accepts defeat for comic effect.

The students laugh.

"Why don't you show us the right method?" Jason asks the teacher.

Acknowledging a student who just wants the answer, the teacher stays his course of developing a formula.

"Slow down," says Mr. Wilchuk, responding to Jason. "Kay, Allen, why didn't you say your method worked for the second one, I'm confused. Your method worked so nicely here."

"Ya, but the second one--."

"Has to have equal sides" says one student.

"Has to have an even number of sides," says another.

"Why can't you just make that into a triangle, too" asks Trevor leaning back in his desk.

The method remains Allen's.

The students continue to puzzle over the question of the pentagon until Mr. Wilchuk assures them. "There's nothing wrong with Allen's suggestion. Just because I have a pentagon, doesn't mean I can't break it up into triangles."

"What about an octagon?" asks Melanie.

"The octagon? I can break an octagon up into triangles" answers her teacher.

"Ya, but how many triangles?"

"Eight," responds Allen beginning to realize that his method works for all regular polygons.

"How do you know...?"

Mr. Wilchuk asks, "How do you know it's eight right away?"

"Count how many sides!" chime three girls in the front row.

The teacher builds in options and acknowledges different preferences.

"Excellent! Why not! The number of triangles, guys, is equivalent to the number of sides. Allen's method should be kind of nice.... Okay here's our problem now. I've got a lot of individuals in front of me and you all like to do things differently. You aren't all using the same triangle formula. So you are going to have to write your triangle formula and then do what with it?"

"Times it by the number of sides."

Mr. Wilchuk continues, "Now, I prefer myself *base times height divided by 2*, but that's me. Will you write down your form of the triangle formula?"

While other students are writing their formula, Jenn asks, "Do you have to write it that way? I can get the same answer by writing *3 times bh* and totally cut out the *divided by 2*"

The teacher promises to get back to yet another alternative: "Jenn's method." He senses that students have enough options for now . . . especially Jason, above.

"Okay, I'd like to get back to that later, Jenn. That's a good point. Can you save that for just a second?" Mr. Wilchuk lets the class know that Jenn has an option. "Okay, Jenn has another procedure. I'm sort of doing what I did with Allen, putting her on hold for a minute."

Mr. Wilchuk goes on, with the students' help, to generate three formulae for area of a regular polygon. They decide to use n to represent the number of sides. (See Figure 5).

$$A = n\left(\frac{bh}{2}\right) = \frac{bhn}{2}$$

$$A = n(bh \div 2) = bhn \div 2$$

$$A = n\left(\tfrac{1}{2}bh\right) = \tfrac{1}{2}bhn$$

Figure 5 - Three variations of a formula for area of a regular polygon

He concludes by saying, "So the various forms of this formula can look

different depending on how you like to write your triangle formula." He gestures toward the overhead. "Any one of those would be fine for any one of these polygons. Now, Jenn said she's got a neater one for this. I'm still going to get her to wait for a second because I'd like to run through and see what the work looks like here first."

"Is Jenn's easier?" Liz asks Mr. Wilchuk.

The teacher allows for the many learning preferences in the room.

"Maybe for her. But it won't be for all. We'll discuss that shortly. Okay, would you please write down one of these three that you want to use and let's do the substitution. I'm going to use the top one: $A=bhn/2$. Now let's see how you substitute the numbers into your formula." Each person in the class substitutes the numbers and uses a calculator to do the math.

Students begin to calculate the area--ten minutes into the class. Correctness is determined by the students.

"1575" says Kevin.

Mr. Wilchuk announces, "I get 1575 from Kevin."

"That's what I got" confirms Gail while others nod.

"Okay, a couple people agree."

Led by Mr. Wilchuk, the class goes on to calculate the area of each shape on the worksheet/overhead. For the pentagon, Mr. Wilchuk uses 1/2 *bhn*....

And Philip asks "Why are you doing it like that?"

"I'm trying to change forms, Philip, because not everybody likes the way I did it the one way."

"The first way's better," replies Philip.

While affirming Philip's opinion, the teacher makes room for others.

Mr. Wilchuk assures him, "That's your opinion though Philip. Not everyone will agree." Then he continues with the pentagon, "Okay, can somebody punch that in and see what you get."

"900 square centimeters" Jack offers.

Again, the students are the authority.

"Jack gets 900 square centimeters. Can somebody else verify that?"

"Ya, it's true."

Mr. Wilchuk proceeds to find the final area, that of an octagon. For this one he uses $bhn \div 2$. Once the class is satisfied that they have the correct answer, Mr. Wilchuk sums up. "This technique will work for any polygon.... When you look up any of these shapes in our math text book, they probably don't have any of these formulae there."

Text books are not the authority.

"Why?" asks a student.

"Because what do most math text books do? They try to write a very fancy formula for that specific shape. So more than likely, I'm willing to bet that, a text book will have a special formula only for hexagons. They'll have another one for pentagons and another one for octagons. Now they may not, but some text books will do that to you... Now, we are getting to what Jenn wants to do. In terms of this first one, Jenn didn't want to use any one of these. So your technique was...?"

The teacher prepares the class to hear Jenn's idea.

Jenn answers, "You just go *bh* times, and then like, half the number of sides. And just totally cut out the divided by two."

Some students join each other to say, "Oooh." They are impressed.

But Trevor looks confused.

This is the second time the teacher notices and responds to a facial expression.

"She's arguing this way, Trevor--" responds Mr. Wilchuk.

"What if there's 5 sides?" interrupts someone else.

"We'll get to that." Then back to Trevor, "Look at this. You are going to multiply by 6, Trevor, and you will eventually divide by 2. What would be equivalent to both of those?"

Trevor says "3."

"Multiply by three. So she can say 'why don't we multiply by three times the base times height of one triangle.'"

Philip's skepticism is accepted.

"It won't work," scoffs Philip.

"You can try Philip, but it will."

Mr. Wilchuk starts a new column on the overhead and gives students an option as to whether or not they write down Jenn's method for calculating the area of each of these shapes. Jack asks, "What if we don't understand it?"

The teacher is calm. Throughout the lesson his voice is soothing.

And Mr. Wilchuk responds calmly, "Well, I'll re-explain it then.... Jenn argues that you can just multiply *three times bh* to get the area of this hexagon. The reason being, Jack, is *6 divided by 2 is 3*. So instead of putting both of those in there, she argues you can just multiply by 3 and it will get you to the same place."

Explaining is also a student task. This classroom is a learning community.

Jenn interjects to explain her idea to Jack herself. "You just divide the number of sides. For the octagon, you get 4."

"In other words, she didn't use 3 again," confirms Mr. Wilchuk.

"So she just divides the number of sides in half?" responds Jack.

Mr. Wilchuk nods.

Jenn asks, "Can I do that on an exam?"

"Yes you can," says Mr. Wilchuk. Then to the class, he explains that text books will not provide what the class has just generated in terms of formulae. He notes that *h* will be called *a* for apothem. Then he suggests that if students prefer Jenn's method, that they can do the same for the next two.

The teacher refers to multiple text books. There is not just one.

"Okay, Jenn, so what's your formula for the second one, the pentagon?" Mr. Wilchuk asks.

"*A equals 2.5 times bh.*"

And eventually Jenn adds that her formula for the octagon is $A=4bh$.

After making note of Jenn's formulae on the overhead, Mr. Wilchuk remarks, "I mentioned this to the other class and I was assuming everybody in the other class would stick to the triangles method. I was somewhat surprised by the number of students that were using these."

I overhear Trevor wonder quietly, "The other class came up with these, too?"

Until this moment, Trevor had been convinced that he and his classmates had discovered something new.

But Mr. Wilchuk continues, "It's totally up to you. For those of you who like Jenn's procedure, fine, use it. If you're a student who says 'Look, I liked what we thought about. We thought about breaking into triangles and multiplying by how many.' Use that method. It will always work. Always."

Mr. Wilchuk invites his students into a learning community. Through conversation, students are engaged in developing the mathematics. They verify and challenge each other's ideas and confer with one another in the process. This teacher is patient and assuring. His teaching allows for multiple ways to approach a question. Mr. Wilchuk is sincerely interested in the students' understanding. And although he has taught for 23 years and knows the "pitfalls" that students may encounter, he does not steer them away from them. Instead, he encourages them toward the pitfalls, using them to prompt discussion and learning. He carefully chooses his opportunities to give information that will guide students further in their knowing. Although his students know that Mr. Wilchuk "knows mathematics" and that in his care they are secure, at the same time, they seem to believe that mathematics is theirs to discover.

Perhaps most telling is Trevor's final question to himself: "The other class came up with these, too?" This is a classroom of amazing mathematical discourse and student–teacher interaction.

Part 2: Taking note(s) and keeping track

Bill Wilchuk calls himself a bit of an "organizational freak." I would call him "attentive"... to his students, to the curriculum, and to his teaching. In this regard, I see "notes" playing an important part in his way of teaching, planning, and learning.

I see Mr. Wilchuk "keeping track" for his students in five ways. First, he prepares careful notes for them, frameworks really, that keep his classes focused during discussions such as the one you read in the previous section. Second, he has a system which guides his pupils to return to their notes at the end of the unit. Third, there are notes on a teacher planning level. Bill, himself, writes detailed lesson plans and, at the end of each day, he notes what worked and what needs improvement. These records are a source for Bill's continuous professional development as he refers to them in future years. Fourth, Bill Wilchuk takes note of what is happening outside his classroom. He attends conferences and workshops frequently and this learning makes its way into his attentive planning and teaching cycle. And fifth, Mr. Wilchuk takes note of his students' preferences.

"Notes"

Mr. Wilchuk knows that his notes are a key to his teaching. Whenever possible, he leads the opening discussion from the overhead projector. And he distributes a copy of the transparency to each student.

"My best lessons are the ones that I've generated the notes for." He hands me a copy of the handout from one of his morning classes. (It is much like the overhead/worksheet from Figure 1.) "The notes help kids stay focused on what we're talking about. And likewise, myself. The notes give direction to both of us. Yet, they don't dictate everything. Students have to fill in a lot of the blanks." He gestures to the empty spaces on the sheet that allow for student input. Then he adds, "The notes get all of us focused and make sure that I've covered everything that I wanted to in a particular lesson."

He goes on to talk about the way he thinks through a tough concept and writes his own set of notes in his planner to guide him. "I make sure I set things up the way I want to see it done. And if I have the time, I'll make up the student notes." He means the typewritten handout (as in Figure 1). "If I don't, I'll get students to just copy. I'll make up the notes myself on the board."

Even when he doesn't have time to make his notes handout, he constructs careful board notes. Down the middle of the board he draws a vertical line. He explains to me, "What's on the right is going to be the actual notes and on the left hand side we sort of just play around with things and experiment." His actual notes distill the math conversation to its essence.

This reminds me of what I observed when Mr. Wilchuk worked at the overhead. There, he was able to "experiment" with student ideas about the area of a regular polygon, and then wipe the overhead clean to experiment with yet another student idea. When the class was confident with the proposed idea, the writing became "notes."

In many classrooms, "notes" suggest the written transmission of information from teacher to student. Not so here.

The notes in this class give direction without dictating.

I'm beginning to see the importance of "focusing" for Bill. The notes help him and his students pause for a careful look. The notes are a record of their thinking. Students can return to them. They can "re-view" their thinking.

These notes are a brief record of the mathematical understanding that is constructed in class. In the notes, Bill Wilchuk takes note of student thinking.

The "notes" system

Mr. Wilchuk's students do not have homework every night. They do, however, have an assignment everyday and, for the average student, enough time in class to complete it. But, for the students who do not complete the assignment, even though they are encouraged to complete it that evening, the work is not "due" or checked the following day. Instead, Bill Wilchuk has invented a system which he

The teacher creates a system that keeps

says allows for the busy lives of his students. He knows that an evening that is free of commitments for one student, is filled with a piano lesson, volleyball practice, and home chores for another.

everybody on track, but allows for individual difference and individual responsibility.

Allowing for the busyness in his students' lives, Wilchuk's system is this. Near the end of a unit, he distributes a checklist (see Figure 6) of all the notes, worksheets, text assignments, and weekly quizzes. Then, students have a few days to complete and gather their assignments for the unit, create a title page, and submit the package to Mr. Wilchuk. They are marked briefly based on whether each component is "incomplete," "missing," has an "incomplete puzzle," or has "work missing," meaning the answers are written but the student has not shown work. This package is called the "notes."

When students do not meet his expectations, Mr. Wilchuk sends a letter to their parents. In it he writes, "Students who can not seem to handle the freedoms of this type of notes system, may be asked to report their assignment completions on a daily basis. In order to keep you informed of any problem areas, I have decided to try a form letter. Only parents of students not completing the assignments properly will receive this letter" (see figure 7). The letter goes on to be quite specific in terms of the student's achievement in mathematics.

Mr. Wilchuk says that he has found great success with this system. Students enjoy the freedom, yet complete the work. The notes system asks students to care about the wholeness of the unit, to think back over their journey. I saw beautifully decorated title pages, even though the title page is marked only for its being there. Students take pride in these documents.

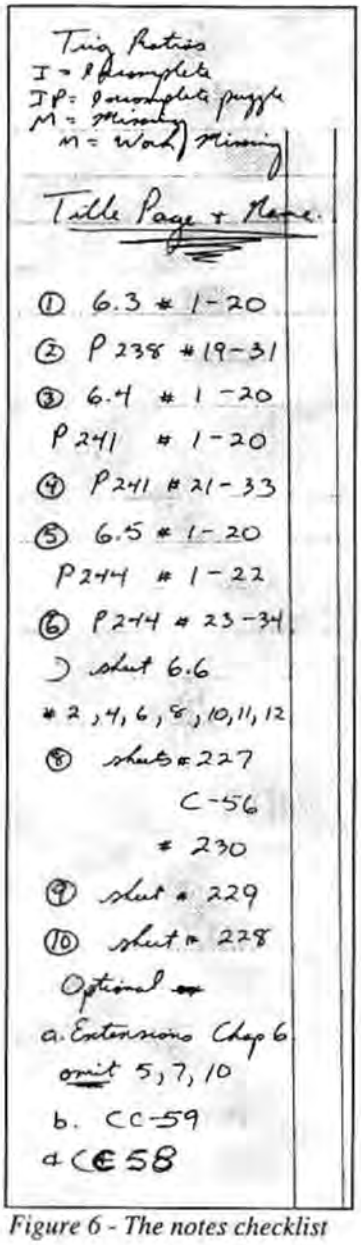


Figure 6 - The notes checklist

Students know that there are two kinds of "notes" in Bill Wilchuk's class. There are the written accounts of the "talking" about a new math idea. (Figures 1-5, for example.) And second, the word "notes" refers to the written and organized record of the entire unit.

Keeping a record is an important student responsibility. They are taught to take notes.

STUDENT MATH REPORT _____

In a typical period students start a class by going over a mathematical concept. Once all discussions on this concept are finished the assignment is handed out and students are given the rest of the period to complete their work.

The assignments are designed so that a student with average ability should have a chance to complete them if they work to their ability. Students who do not finish in class time must do so on their own. If additional help is desired all they need to do is ask. I am available before school starts, at noon hour and also after school. When a student chooses to complete their assignments it's left with them to decide upon. My only requirement is that they have their work properly done before I mark their notes.

Students who can not handle the freedoms of this type of notes system may be asked to report their assignment completions on a daily basis. In order to keep you informed of any problem areas I have decided to try a form letter. Only parents of students not completing the assignments properly will receive this letter.

The last chapter notes marked were on _____.
In this unit _____ received a mark of _____ on the unit test and a mark of _____ on the unit notes handed in. There were _____ assignments that were either not finished or were not finished as was instructed.

Please sign this letter and send it back to me. Feel free to send additional comments or questions as well.

Parents Signature _____.

Parents are encouraged to take note as well.

Figure 7 - Letter to parents of students who do not meet the expectations of the notes system

The planner system

"Basically when I write up the lesson, I'm sort of an organizational freak. I like to rehearse. I like to know what's going on. I'm one of these guys that has a plan book for every grade level I teach." He picks up two thick coil bound books. "So this is last year's. This is this year's. I basically flip though and see what I did last year and quite often I'll have written little comments to myself: whether or not things worked well, things that didn't work well, I might write 'my lesson was too short,' or 'it was too long.' I like to keep stats all the time."

He explains his idea of "rehearsing" prior to a class, remembering when he was a younger teacher just coming out of university. He smiles as he admits, "After you've taught for one or two years you think you know it all. I'd go into class saying, 'Fine, I know how to teach this topic.' And I'd just go ahead and start. And then after I had finished, I'd look at some of the questions the kids asked during the assignment and I'd realize, 'Oh, rats!'" Bill slaps the table. "'I didn't cover this' or 'I didn't cover that' or 'Gee, I should have said this.' So I soon learned that maybe I'd better spend some time and look at the different things I want to make sure that students fully understand. So that's what my plan books do for me." The plan books frame his reflection.

Even though Bill has taught for 23 years, each of his lesson plans is one page long. And each year he recopies it, revising it according to the notes he made the previous year. "By recopying my notes from one year to the other, I will get some people saying 'Well, gee, that's a waste of time. Why not just keep one copy?' But I modify all the time. And it's a way of practicing for me as well."

"I let kids direct me to a certain extent, but I still have things I want to cover."

Before lessons, Mr. Wilchuk uses his planner to "rehearse." (He writes detailed plans, every day, every year.)

After lessons, he takes written notes of his own teaching practice. He values continuous professional development.

This practice grows out of his natural inclination to look back on his teaching. He takes notes, then returns to the notes and lets it shape his future actions.

Recopying and revising are ways of rehearsing. His planning is recursive.

Mr. Wilchuk has a clear plan, yet, as we saw in his lesson about area, his students feel that they create the math. He remains responsive.... He remains attentive.

Taking note outside the classroom

In my interview with Bill, I try to get him to talk about his ability to create mathematical conversations, but he skillfully avoids the question....

I wonder if modesty has something to do with his success.

"I think, we have a lot of super individuals practicing in the field of mathematics.... I noticed one of your questions has to do with, well, 'What is the greatest attribute that contributes to your success in mathematics?' I think it would be my willingness to change and adapt. I try to re-learn or learn more about the material. So, I definitely make a point of going to as many math conferences as I possibly can. And there, as I say, you have all sorts of super people in the field." He looks at me and shrugs, "Most of what you saw... a lot of that comes from just ideas I have borrowed from other individuals who I think are doing interesting things."

He is open to the practices of other teachers. He seeks them out. He takes note.

"And I experiment. What goes well I try to develop farther. What doesn't go well I throw out!" He laughs. "So, I think the ability to adapt is probably one of my strongest attributes...."

He gathers and refines.

Taking note of kids

And just how does he determine what "goes well" and "doesn't go well"?

Bill says, "I can read kids and see what they like and what they don't like. And that helps an awful lot."

He not only takes note of student thinking, as we saw in the transcript in Part 1, he takes note of student preference.

Bill Wilchuk tells me about the various materials he has tried over the years. He uses algebra tiles because his kids like them. He tried Cuisinair rods, but found they did not work for his students. He continues to use the Pizzazz worksheet series saying, "Kids love the puzzles. And, hey, whatever motivates them!" Additionally, for the past several years, his grade nines have built "geo-ring polyhedra." (They hang colorfully, some of them 40 centimeters in diameter, from the ceiling in Bill's room. They add a sense of promise to the math classroom.) But this year, students were not as keen as they had been in past years. "The vote barely passed," Bill says. "So next year, I'll have to think of something else."

By watching and listening to his students, the teacher knows what works.

Bill Wilchuk notices his students in a significant way.

Part 3: Learning within a complex system

Mr. Wilchuk's teaching happens as part of a complex set of interconnected factors. His school has a distinct personality. Students are polite. They open doors for adults without being asked. And teachers are committed to the school, to each other, and to teaching. As well, Mr. Wilchuk is fortunate to work with a principal who believes in him. The school is clean and fairly new, built in 1985. It exists within a community in which people are friendly to each other and the population is stable. Additionally, Mr. Wilchuk's students learn within a unique district which operates in accordance with the values and policies of Alberta Education. Also implicated in the learning, is the local economy, one which places a high value on mathematical knowing.

A Norman Rockwell community

Mr. Wilchuk teaches at Gilhooly Junior-Senior High School in the town of Gilhooly. The town has a population of less than 1000 and is located near a small urban center.

Gilhooly itself is small. Driving into town, I see a hand painted sign directing me to cross the train tracks before turning to access Gilhooly. I do so, but by mistake, I arrive at the elementary school which, I discover, is just up the hill from the junior-senior high. Between the two schools, on a hill that spans one town block, is a large and busy curling rink, a center for town activity. And down the block from the elementary school is main street. There is a hotel and bar, a cafe, an automated teller, an insurance agent, a Chinese restaurant, and a Lucky Dollar grocery store.

Everything is described in relation to something else. Things are connected.

Smiling, principal Dwayne Farthing tells me that I can get a "fine and greasy" breakfast at the cafe in the hotel. On Friday mornings, he says, principals in the area meet there for breakfast on their way to district meetings. I find that the waitress in the cafe knows the names of all her customers. As the various regulars arrive, they are greeted and cajoled. In the evening, after the cafe has closed, I ask if there is a pop machine. The hotel clerk says no, but then kindly unlocks the cafe to sell me a soft drink out of the cooler.

Relationships are important.

People are connected.

Down the street, half of the grocery store is dedicated to video rentals. There is a small selection of groceries. And by the entrance is a bulletin board, littered with advertisements for baby-sitting services, cars, kittens, and concerts. On the step outside the store is a young boy with an eight-week-old puppy. He lets me play with the puppy and tells me that he is minding the new pet while his brother is inside buying snacks.

And in the staff room of the junior-senior high, I overhear several teachers talking about the possibility of a gas station opening up. They are pleased.

Valuing education in Gilhooly:

Students who are ready to participate

The Gilhooly Junior-Senior High Newsletter (March 13, 1998) is a low key document. Two of the articles congratulate student and teacher accomplishments in curling. (The coordinating teacher is Mr. Wilchuck.) "All curlers received T-shirts," says the article. Acknowledgments go out to families and businesses who have donated prizes and trophies. After mentioning a third place finish for the high school team at the provincial championship in Grande Prairie, the letter reads:

> The Gilhooly curling team were excellent ambassadors for Gilhooly Junior-Senior High School and received many compliments for their curling skill and sportsmanship from fans in Grande Prairie. The team worked very hard all year, and should be proud of their accomplishments.

Of the six articles, five celebrate extracurricular involvement. The other asks parents to complete a yearly survey.

Families and businesses support school efforts.

Participation is rewarded with prizes and newsletter recognition. The focus is on sportsmanship, citizenship, and hard work.

Another article invites the community to the Student's Union Penny Carnival. It promises:

> There will be games such as Pin the Tail on the Donkey, Toss the Ring on the Bottle, and Balloon Shaving. There will also be a fish pond, lots of prizes, and a hotdog stand if you get hungry.... Admission is just 25 cents per person.... This is our first annual Penny Carnival for the whole community and we hope to see you all there!

The school is a community center.

The principal says that over 65% of the junior high girls played extracurricular volleyball this year.

Students take some responsibility for school events.

The school values students participation. Students and parents appreciate school opportunities.

Since most of the students come from the outlying area, I am surprised by the number of them who are willing to return to school for my evening drama workshop. In front of the school, I see oodles of mini-vans dropping off young people to participate. I am further surprised by the behavior of the students. Four of them arrive early to help me set up. And although a Gilhooly staff member is in the school to ensure everything runs smoothly, I am, for the most part, alone with 27 students ranging from grade 7 to 12. The students are comfortable with the range of ages. They work with each other willingly. It is easy to get their attention. They share their work with pride and take suggestions well.

Teachers who take pride

The industrial education teacher, Brent Millar, is eager to help me gather some supplies for my drama workshop. And while in his lab, I am given a tour of the various student projects under construction. Then, Mr. Millar disappears for a moment, returning shortly, carrying what he calls his "brag book." He opens it for me, revealing a collection of precious pictures of student work in his lab.

Teachers help each other.

Helping students be successful is a source of pride. Students' lives affect teachers' lives.

Among his several glowing accounts of student success, he tells me about an ornate clock and the student who built it. The student died shortly after. Mr. Miller has not used the clock project since then.

Teacher pleasure, student learning, and building aesthetics are all one.

On my way out, he shows me the adornments that he is adding to his classroom doorway. He teaches me about "plinth blocks" and "crown moldings." The doorway is an opportunity for him to teach his students some new vocabulary. "And it looks good," he grins.

An economy that values mathematics

Seeing the importance of mathematics to the local economy and to their parents' livelihood, students learn math with purpose.

In the staff room, Rod Mathews, a social studies teacher, explains why he thinks the school does so well in mathematics. He says that the parent community values education. Rod says that parent support is greater for math and science than it is for, say, social studies or language arts. "For example," he says, "in social, I've heard kids complain, 'Why do we have to learn this?' Whereas, in math, they know why." He explains that Gilhooly is located in the oil patch. So, most of the parents work in the oil industry where math is important. "Many of our students aspire to be engineers."

And the results support Mr. Mathews' thinking. Although all of the grade 12 results are over the provincial average, students do slightly better compared to the provincial average in math and science than social studies and English.

Families that provide for students' needs and care about education

Dwayne Farthing, the principal, says that one quarter to one third of the school's students come from traditional farm homes. Another quarter to one third come from surrounding acreages, "which on the one hand means they are fairly middle class, if they can afford to be on an acreage, on the other hand, they've got no connection with Gilhooly other than this school. Their parents are working in the larger center, Bainbridge. So it has it's ups and downs. We have fairly traditional sorts of kids. We are also a low housing district for Bainbridge so we have some transient families. Probably not as much as Bainbridge itself though."

Of the 11 sets of parents who returned our survey, all said that they had lived in their present home for more than three years. All who answered said that at least one parent had some post secondary education. Eight families reported an income of over $40 000.

Almost all parents attend parent-teacher interviews.

Dwayne also tells me that at their last parent–teacher interviews, they had a 96% attendance rate. He attributes this success to the type of parents that the school has, but also says that the school has a good system for preparing and distributing report cards. A couple times per year, parents come to the school to personally receive their child's anecdotal report card. He suggests that the high attendance at interviews might have an indirect impact on achievement.

A timetable that offers access to Mr. Wilchuk and more time for junior high instruction

The principal values Mr. Wilchuk's teaching enough to make timetable adjustments so that all students in the junior high have him as their teacher.

Dwayne has also assigned Bill Wilchuk all the junior high math. This allows Bill to focus on the program, but also allows all the kids in the junior high to benefit from his teaching. This assignment is not as simple as it sounds, however. All the junior high math amounts to one class more than teachers in this district are contracted to teach. To reconcile this, Dwayne himself relieves Bill every second day with a different learning group each time.

The timetable happens to support "achievement" but is really tailored to suit the students and families who rely on buses. This is a community based decision.

The principal tells me that one of the possible reasons for his school's success is the extra instructional time that the school offers in junior high core subjects. He explains that the timetable is not as much a response to achievement goals as it is a response to community needs. He says that Gilhooly schools rely on buses, a fact which demands that start and end times for the elementary, junior high, and senior high must be coordinated. The school act requirements for instructional time increase from elementary to junior high and from junior high to senior. "So to reach the required instructional time for high school, our junior high actually ends up getting somewhat more than the minimum. We don't have recesses. Our elementary barely hits the minimum because, within those same start and end times, they have recesses. The high school also hits the minimum. Junior high is a bit extended."

A district that values professional development

Hearing Bill talk about his continuous professional growth, I ask Dwayne Farthing about school and district policies in this regard. He says, "Before school based budgeting, the district allotted a certain number of sub days per teacher. And if you didn't use them up for sick leave, you could use them for PD--and only for PD. Historically, this staff used very little sick leave, so we were rich. We used to go on overnight retreats. We're not that rich anymore, but nonetheless we continue to put quite a lot of money toward PD on that same sort of principle... more than most schools in this area. And so, there is quite a bit of financial support."

District policies, even ones that no longer exist, have impact on the teaching and learning in Bill Wilchuk's classroom. The now gone PD policy encourages Bill to make professional development a habit.

He goes on to say that the school still puts surplus substitute money toward PD, but "not on an individual basis. I think our PD budget is about $450 a year per conference, not including sub costs. That's more than most jurisdictions."

School policies are influenced by district ones.

The present is influenced by the past.

A principal who values his teachers... and community

In talking about his relationship with teachers, Dwayne reveals his own growth as a

In the interview, I ask Dwayne Farthing what he thinks is the greatest asset of his school. He says without hesitation, "Teachers." Then, he adds, admitting that he is being political, "Another great asset is the community. Strong traditional support."

principal. He too has been affected by the spirit of professional growth in this district.

And he discloses the complexity of this school community. He has been in Gilhooly for 14 years. Bill has been here for 22. Teachers are the community.

Then he returns to talk about his relationship with teachers. He says, "I rely on them." He recalls the days when that was more literally true for him. "I have practically been here forever now." He pauses to think, then adds, "this is my fourteenth year. When I came to this school as principal, I came straight out of the classroom. I had no other experience. And I know when I started I was probably 'a teacher's principal.' I think I've found a much better balance between student, teacher, and community. Nonetheless, I would expect that the teachers feel that they are masters of their domain. And that they have a reasonable amount of support from me, I would hope."

A district that has some bureaucratic responses to provincial policy

Dwayne groans at the phrase "district policy." He claims that he is "none too familiar with the policy book."

One of this district's priorities is achievement. Dwayne explains that this means "achievement test results." He says that they don't go overboard, like he has heard some districts do. He tells me about the analysis of achievement results that the board asks his teachers to do. The exercise is a good one, but Dwayne questions that lengthy report that follows. "This year 8 pages looks good. Next year, it's 10...."

Despite his criticisms of the lengthy report, Dwayne seems to see inside the task the value of reflecting on the curriculum and student performance.

The paper work seems to be getting in the way of running the school.

He talks about his own report writing. "We are getting into the 55-page report cards. The government came out 2 or 3 years ago and said we had to have a three-year plan. Then a report card to follow up. Well our board turned that into a 55-page effort. Not linked specifically to the budget, but certainly we have to set goals.... And I find that a bit of a joke, frankly. Our goals for this year, in terms of achievement, are to be above provincial average in every test written.... What other goals do you set? If you hadn't been above in any, I guess you would say, well, two of nine would be good."

And I am drawn to compare the paper work here to the "notes" in Mr. Wilchuk's class, or the anecdotal report cards which attract parents to interviews. Although, all three are records of human knowing, they are also different. The notes and report cards seem to have an authentic purpose. The notes are tools that allow students to develop their thinking. The report cards are also tools, this time to communicate and celebrate student success. But the district reports are perhaps for no one, just proof that a job was done. Not a tool, a bureaucratic obligation.

A school that is not focused on achievement results

In the same way that involving 65% of the girls in volleyball is more important than winning,

Although Gilhooly Junior-Senior High School sets goals related to exceeding the provincial average on the achievement exam, when asked if that is a target in itself, Dwayne says, "I would hope not. I would hate to think we were a school driven by tests....

Gilhooly School does not let the test drive the students' education.

Achievement tests don't necessarily reflect curriculum or a lot of the good things happening in classrooms. So I would hate to say we were driven by them. It's nice that we do well on them. It's a concrete standard, but not necessarily a very accurate one."

Bill Wilchuk agrees. He teaches the students. He teaches the curriculum. (But he admits that as the test draws nearer, he is influenced by his desire for students to do well.)

An appreciation for individual choice and difference

Dwayne tells me, "My teachers generally would say they were very empowered to operate their programs. They are the experts. This might be a deficiency on my part, on the other hand it's worked out fairly well. I'm surviving.... But, certainly, Bill tells me what he wants to do. I don't attempt to tell him."

I am reminded of the choices that Mr. Wilchuk builds into his teaching. He prepares for individual difference and preference. He gives choices.

Dwayne's appreciation for difference is realized in simple ways. There is not a school wide rule, for example, governing the weight of achievement tests in teachers' marks. But, the respect for individuality is seen in more complex ways, as well. For instance, he talks about teacher evaluation in which one of the criteria is "student ownership." Being an English and social teacher, you probably think, 'Oh that's easy, I should be able to see that because they will be doing group work and they will be choosing from a range of possibilities....' But when you go into a math class, you think, 'Well, how am I going to see that here?'"

Dwayne works at seeing beneath the surface of teachers' work. He sees beyond his own strengths and biases as a humanities teacher. He admits that he must "work a little harder" to really see. And I am reminded again of Bill's class. He too stops to notice... the math with the kids... and the kids with the math. Both at the classroom and school level, people are working hard to take note of (and with) others.

"When I go in to see my high school math teacher, who is also exceptional, and his class is fairly teacher directed. He knows what he's going to do and he's up talking to the class a lot. Then, students have some work time, in which case, they are quite welcome to work together or share. I don't think I've seen anybody do a better job of getting kids involved and responding."

Then he jokes dryly, "Either that, or it was just a good day."

"There are different ways of giving ownership. If you come from one particular perspective, you might have to work a little harder, but it's probably happening."

I ask him if he has any advice for other principals. And he says, "Assume you've got good people in place. I think we can lose sight of where learning occurs. And of course it can occur anywhere, but in the classroom is still where it's at. So a principal had best try to rely on classroom teachers, encourage what they have to say, and give them a lot of freedom with what they are doing. Try and insulate them from all of the demands from outside to allow them to have the energy to do their job."

Students and parents who reflect on mathematics learning:

The parent questionnaire

What do you think makes the biggest difference as to how well your child does in mathematics?	Many respondents gave lists of several factors in their child's success. • 9 parents credit the actions of the teacher • 5 parents attribute success to the student's actions and effort • 1 parent cited help at home "how many questions he asks at home" • 2 parents mention their child's "understanding," without actually saying how that occurs	*Even though the principal and teachers believe that parent support is a huge factor in the success of students in math, and, more generally, in school, only one parent talks about the influence at home.*
What does the teacher do to help your child?	• 3 parents cited extra help from the teacher "The children have access to him at school, during breaks, as well as at home." • 4 mention clear or detailed explanations • 2 say the teacher ensures their child's understanding	*Parents have a sense of what happens in the classroom.*
Can you think of anything else the teacher could do to help your child with mathematics?	• 10 parents said "no" • There were two ideas for improvement: "more individual attention" "pick up on the problem more, rather than waiting for the student to ask for help"	*Parents, generally, have confidence in their child's teacher and in the math program.*
What factors and school policies affect your child's success in mathematics?	• 5 parents cite a strong school staff or a strong teacher • 3 mention student effort or interest • 2 credit home support • 2 say extra help • 1 thinks worksheets make a difference • 2 talk about student understanding • 1 thinks that the school attendance and discipline policy is important	*Parents seem consistent in their perception of the hierarchy of influence on mathematics learning: first, the teacher; second, the student; and third, the home.*
Do you think that your child will be prepared for the provincial exam?	• 10 parents say "yes" crediting either the teacher or the student for their effort "my son has been part of an excellent math program for the last 3 years" "if she keeps up the attitude and work ethic..." • 1 says "no" with no explanation	*(Mr. Wilchuk is the grade 7, 8, and 9 math teacher.)*

The student questionnaire

What does your teacher do to help you learn mathematics?	• he is "thoughtful" • teaches in class: "giving an understanding of formulas" "discuss new concepts every day" "explains things real well" "step by step" "goes over new concepts slowly"	*Students value kindness.* *Students value detailed explanation.*

"he won't let us work unless we understand what we are doing"
"he goes through everything"

- uses student ideas
- answers student questions
- gives choice:
  "doesn't make us do it his way, we get our own way that we like"
  "let's us work in partners"
- repetition
- worksheets
- review
- notes and lots of examples
- shows diagrams
- walks around and provides one-on-one help:
  "explains things again and again if you don't understand"
  "helps us, but not by giving the answer"
- lunch and after school help
- help to study for exams
- weekly tests

. . .

Students like being included and having choice. They think it makes a difference.

Students like to talk about math with friends. They like being part of a community of learners.

They value review and notes.

Students see that Mr. Wilchuk helps <u>them</u> come up with a solution.

Students see what is going on in this class! They take note.

Students suggest:
extra help,
detailed explanations,
peer interaction,
routines,
high expectations,
lots of options,
and a teacher who cares about them.

Students want to be reminded of the future that is implicated in the present.

To their peers, students number one suggestion is "pay attention and listen." Second in frequency is "ask questions and get help." And third is "work hard."

Advice to grade 8 teachers?

- provide extra help after school and at lunch
- give some time to read about the math unit
- explain "slowly and precisely"
- "talk before each class about a concept"
- "let the children go in partners because they can ask their partners questions"
- "use Mr. Wilchuk's 'formula, substitution, answer system'"
- "make sure kids show the work"
- "do more interaction"
- "teach from all different angles, show more than one way"
- "make students ask questions"
- "be patient and understanding"
- "deal with trouble makers"
- "make math fun by listening to music and working in partners"
- "tell your students that grade 8 is the building block to grade 9"

Advice to students?

- pay attention, listen
- ask questions and get extra help:
  "ask Mr. Wilchuk for help"
- "work hard and don't slack off"
- review often
- "do extra assignments, it helps"
- "show your work"
- remember technical terms
- study
- "don't miss classes"

So, Bill Wilchuk's teaching and the learning of mathematics that takes place in his classroom are affected by many factors. Parents and local businesses show their commitment to education by donating trophies so that students who get involved in extracurricular activities can be rewarded. Parents take time to drive their children back to the school in the evening so that they may take part in other learning opportunities. Almost all parents attend parent–teacher interviews. Many have some post-secondary education. Most are financially able to provide for their children's basic needs. Compounding the parental support for education is the focus that the Gilhooly and area economy places on mathematical proficiency.

The school and its district are also important in determining the success of Mr. Wilchuk's students. The school timetable affords mathematics more time than the province mandates. The principal arranges a special timetable for Mr. Wilchuk and himself so that all junior high students can reap the benefits of Mr. Wilchuk's teaching for the three years that they are in junior high. The principal has great faith in his teachers and the surrounding community. He works to appreciate the diversity in his staff. Mr. Wilchuk's fellow teachers at Gilhooly Junior-Senior High School take pride in their work and see themselves as part of the community they serve. Outside the school, the district has a history of providing teachers with sufficient money for professional development. And despite the district focus on achievement on the provincial tests, the school does not let the tests "drive" the school.

Parents have confidence in Mr. Wilchuk and have an understanding of what happens in the classroom. Students are articulate when it comes to describing the goings on in math class. They too trust Mr. Wilchuk's methods. And they know that they have responsibilities in the learning process: pay attention, ask questions, get help, and work hard.

In this context, Mr. Wilchuk teaches math. Under these conditions, his students succeed.

Conclusion

The success of the students at Gilhooly Junior-Senior High School is a product of a strong teacher, working with students whose home needs are met, alongside a principal that supports teachers, and within a community that supports education and knows the economic value of mathematics.

Inside the classroom, Bill Wilchuk engages students in the world of mathematical thinking and does so remarkably. The conversations that I witnessed show young people completely involved in inventing mathematics. For Bill and his students, math is inside them, waiting to be worked through. This teacher encourages his students by giving them credit for their thinking. He allows them to learn from their own mistakes. He accommodates their differences. He is patient and calm.

Additionally, Mr. Wilchuk's attention to detail serves him and his students well. His preparedness with regard to lesson planning and the "notes," his daily reflections and rehearsals, his yearly lesson revisions, and his ongoing professional development are evidence of his highly thoughtful way of being a teacher. As well, his interactions with students are strengthened by the attention he gives to their responses. He looks to them to see what he should keep or throw out. He looks to them, as I saw in his mathematical conversations, for the substance of the lesson.

This is a teacher, a school, and a community from which we can learn much.

Six

O'Brien Junior High

Joyce Mgombelo

O'Brien Junior High is located in one of Alberta's largest urban school districts. It is attended by more than 700 students. Most of the students come from the surrounding middle class community. Data from parents' questionnaires indicates that more than 75% of the parents have a combined income of more than $40 000 and at least one parent from each family has completed post-secondary education. According to Miss McInnis, one of the math teachers and Mr. Kendrick, the Vice Principal, O'Brien draws students from a good environment. Parents are success oriented and students come to school highly motivated and pressured by their parents.

In addition to the good environment, Mr. Kendrick suggested the following factors contribute to the success of O'Brien Junior High. First the school encourages and makes opportunities for the teachers to engage in reflective practice. Teachers are strongly encouraged to reflect on their teaching. The principal, Mr. Don Harke, leads by example. Teachers are expected to plan for their own professional development. In other words, the school recognizes that professional development is personal development and thus empowers and supports teachers to make their own decisions and makes arrangements to enable them to attend seminars they believe are most useful to their professional growth.

Mr. Kendrick also described a school organization in which teachers are encouraged to get to know their students well. The school recognizes the strengths and weaknesses of specialist and generalist teaching systems. He said, in a specialist system, it is not possible for the teachers to understand their students as well if they see them for teaching a single subject only. Whereas in the generalist system teachers see the students more and thus have the opportunity to get to know them better. However, in the generalist system, students may become disadvantaged by being taught by teachers who are not experts in their subjects. Therefore, a balance between the specialist and generalist teaching system is preferable. At O'Brien, arrangements are made so that a group of specialist teachers stay with students for three years (Gr.7, 8 & 9). That is, a group of teachers, say two math teachers for example, will teach the same students from grades 7 through 9.

With regard to students with special needs, the school has a system in which students are identified and placed with a teacher in a small group. In this setting, a resource teacher helps students in a one-on-one basis with their problems. For academically successful students, the school has had a system in place in which grade 7 students are identified as strong in math. These students are put on a fast track so that by the end of grade 9 they have advanced placement for Math 10. This practice is being phased out because of the introduction of the new curriculum. Ms. McInnis indicated that the repetition in the previous program was unnecessary for strong students, so there was a need for the advance placement work. The new curriculum does not have this

redundancy, thus strong students are more likely to be challenged with the program as it is.

Other factors which may contribute to the success of O'Brien include extra hours in math (beyond the Alberta education requirement), as well as a timetable in which math teachers are able to see their students everyday. In addition to this, the school ensures that resources like computers are available. The school organizes fund raising activities to generate money for such equipment.

Miss McInnis

At the time of the study, Miss McInnis was in her seventh year of teaching. She earned her BEd. in 1991, majoring in math. Her teaching load at O'Brien included grade 7, 8 and 9 math and some health. Miss McInnis enjoys her teaching, and accepts the challenge of teaching the two regular grade nine classes (rather than the advance placement classes). There were 68 grade nine students divided into two classes of 34.

The classroom is in a portable with no windows but is brightly lit. Inspirational laminated posters cover the walls: "Math is strength in numbers;" "Anyway you add it up...math counts." In one corner of the room there is a teacher table. On the teacher table, one might find several folders, student's projects, a tray containing dice, coins, scissors and the like. This is Miss McInnis's home room.

On the day of my first visit I saw both classes 9B and 9G. The bell rang, which was actually a music emanating from the intercom high on the wall. Students arrived in small groups taking up their seats around tables. Miss McInnis greeted them without interrupting their conversations.

Within a few minutes the room was filled by students and noise coming from their various conversations. Miss McInnis called for attention. She then did what I would call house-keeping activities. She introduced me and the other researcher and reminded them about the research project. She also reminded them of a re-test for students who needed to upgrade marks on one of their two tests from the last unit. She mentioned an upcoming test and she informed them that she would be absent on the next day and Mrs. Harke was going to substitute.

At the time of my visit Miss McInnis had been doing a unit on Data Analysis using the "Minds on Math" text with her grade nine students. This year she was teaching this unit after a unit on algebraic operations and equation. She commented to me that she had decided to do this for a couple of reasons based on her experience with the previous year's grade nines. Firstly, students perceived data analysis as "not really math" and she felt they lost interest in learning math right from the beginning. Secondly, since students select high school programs early in spring it makes sense to teach the algebra unit prior to the high school placements.

Miss McInnis instructed her students to refer to the previous day's activity. The activity was written on the board. (see figure 1.)

The paper cup activity

"Yesterday we did an activity with a paper cup. We recorded the results for the paper cup for the whole class. I didn't go through all the information. We are going to look at it today. Look on page 86 on making predictions."

Students picked up their folders and books. Miss McInnis was referring to the activity on page 86 (In Minds on Math). Students had done parts a, b and c. On part c of the activity students had combined all their results for the whole class. She was now leading a discussion towards part d of the activity on making predictions.

Activities: Record the results for each activity in a frequency table.

1. *Complete the paper cup activity on p. 86. Find the relative frequency.*
2. *Using two dice toss the dice 40 times and record the sum on each toss. Calculate the relative frequency of each sum.*
3. *Explain what relative frequency means/does. What is it used for.*
4. *If you were to toss the dice 300 times how many times would you expect a sum of 2?*

Figure 1

"On making predictions. On the tail. When we were talking. When everybody was talking. We were talking of 560 times." Miss McInnis reminded her students of the total number of times the paper cup was tossed for the whole class (part c of the activity page 86 Minds on Math).

"On the tail. How many tails total for the whole class?," Miss McInnis asked.

"What tail?" one student shouted.

As soon as the student exclaimed, Miss McInnis realized that tail was not an outcome. This activity had three outcomes—the cup could land on its top, bottom, or side. "Tops. I mean," she corrected herself. She then quickly reviewed the relative frequencies of the different outcomes with the students (paper cup activity part c, page 86).

"I am gonna start with Teddy. On the top. How many tops total for the whole class?"

"59." Teddy answered.

"59, which is what as a–"

"10.5%."

"0.105, if you write it in decimal. For the bottom. How many times did it land on the bottom?"

"29." Another student, Jimmy, answered.

"29, which is equal to what?"

"5.2%."

"0.052, in decimal. Okay Eddy. How many times did it land on its side?"

"472." Eddy replied.

"Which is equal to what?"

"84.3%."

"Right or 0.843 if you write in decimal."

After Miss McInnis and her students reviewed the relative frequencies of the different outcomes, she then moved on to her initial aim. That is, on making predictions, part d of the activity. She approached this by asking a question with a different data set than noted in the book.

"Here is my question then. If we've got 59 times out of 560 and we tossed the cup 150 times, how can we figure out how many times we expect it to land on top?"

Students began to work on the question. Others were conversing with their partners on the table. Some took out their calculators. Miss McInnis continued to probe. "How do I set up then? What do I need to set it up?" Students continued to work with their partners on the table.

Within a few minutes one student tried to speak but with a very low voice. "What are you trying to say?" Miss McInnis asked addressing the student.

"89 times," the student answered.

"You have the calculator. If you toss it, it can't land on its top more than half of the times." She corrected the student.

The dice activity

Students continued with their conversation and Miss McInnis decided to move on to the second activity on the dice, question 2 on the board (figure 1). "For the dice–" she raised her voice trying to speak amidst the noise coming from students talking to each other. She then waited for students to calm down and continued, "For the dice. You guys each have different information. We didn't do it as a class." Addressing one student she asked, "Eddy, how many times did you guys get?"

"We didn't get it all." Eddy replied.

"Sam, how many times did you get?"

"15 times."

"So how many times did you expect to get it out of 300 times?"

"15 times."

"Did you do this?" Miss McInnis asked Sam and his group suspiciously.

She continued, "So if you guys did different things. So they [Sam's group] tossed 300 times and they still get the same 15 times based on 40 times. Based on what we predicted, is that realistic?"

Several students tried to answer the question but they could not be heard. Miss McInnis answered herself, "No. Probably not. It is possible but it is not realistic."

Back to the paper cup

At this point Miss McInnis paused to see what she and her students had done so far. "I think we've done most of the questions already. Okay question c, we've done. Thats what we worked out first." She thought aloud. She then moved on to the next question.

"They are now asking you the same question. Taking all your results and saying now we've got 400 times. How many times do you expect the same result to happen. So how many times do you expect for the top to land out of 400 tosses? You had 10.5% for 560."

"42 times." One student spoke out.

"You expect 42 times on the top. How many times do you expect to land on the bottom? It was 5.2%."

"20." Another student replied.

"20. Right. 20 times land on the bottom. It was 84.3% for the side."

Before a student could answer the last one, Miss McInnis decided to end up activity. "If you can't do it, set it up and you do cross multiplying as you did in grade 7 and 8. All we are doing is taking easy math and placing it where it can be used."

On the Uses of statistics

After Miss McInnis and her students completed reviewing part d she moved on to question 3 on the board (figure 1). S he asked one student to read while others listened and followed along, the section on "Through instruction" in "Minds on Math" page 86. One student started reading the first part, on the uses of statistics in making predictions.

As soon as she finished reading, Miss McInnis commented on what she had just read. "This is what helps us decide what to keep on hand at the blood bank."

"Let us think of the wheel of fortune. Typically what people do, they actually go to the same letters, either an a or o. Usually they have no idea if they will get it. And then they guess usually an n right – This is my grandma's favorite show. What is the other letter they guess?"

"B, Q, P, J–" various students shouted out their responses.

"Anyway what they are doing is that they figure out the frequency of– figure out the letters which are used more often in the English language. The letter with the higher frequency will probably be used. They work backwards trying to use math."

Miss McInnis asked another student to read aloud the rest of the section on "Through Instruction." In the same fashion she commented on what the student had just read. "This is what we did yesterday.... We found the relative frequency of the outcome.

We found the relative frequency of how many people show up at school. How many people pass, how many people fail–"

Computer application

Before assigning homework Miss McInnis moved to the computer application in the text book. She asked students to flip over to page 88, on using a computer in "Minds on Math." She explained the use of the computer in simulating random data. "You can type =RAND(2) and the computer will generate data for the coin. If you want for a dice type =RAND(6). You can do this at home. I am not a genius but there is probably a way where you can figure out the formula to generate data."

Assignment/homework

Having completed the instructional part Miss McInnis wrote questions for homework on the board (figure 2)

p. 89 # 1, 3-7, 10, 15
Choose one of # 17 or # 20 for bonus

Fig. 2

Some students began to work. Some started conversing with each other around the table. The conversations fluctuated between their assignment and their social life. I could hear the two girls sitting close to me discussing their social life. But I could also see them doing and discussing their work assignment. One boy chose to work on his statistic project. A nother boy was doing almost nothing.

Miss McInnis was circulating around the room, visiting each table. She was checking homework and recording in her gradebook. She was also answering students' questions and helping them with their work. The room was filled with "noise" emanating from students' conversations. I watched Miss McInnis moving from one table to another. She seemed not to be bothered by the noise. In fact she seemed to be able to hear various students over top of their voices and occasionally commented on their conversation. "Danny I heard you. That's not true." She said to a boy from a table next to where she was working with a student.

Within a couple of minutes I could see pairs of students tossing pennies and dice, indicating to me that they were doing the two bonus questions. As the class came to an end, some students had finished their work. Some were still working. Once again Miss McInnis reminded them of the re-test and the upcoming test.

Understanding Miss McInnis' teaching practices

The account of Miss McInnis' class is specific to one classroom on a particular day. The first day of my visit. One might take this account as typical of Miss McInnis' classes and thus representing her teaching practices. But it is not the typicality of the classroom that taught me about Miss McInnis teaching practices. It is the particularity of

the class. For example, I wondered why Miss McInnis' classroom was arranged in groups of tables. How was this significant in terms of teaching math? Unlike many math classrooms, Miss McInnis' students are allowed to talk – to make noise. In fact, I dare say that this was not noise for Miss McInnis. I was curious as to why this was the case. What was its significance in the teaching and learning math?

Promoting conversations in the classroom

It is very common to find in a classroom, desks or desk-chairs arranged in rows. Occasionally teachers in these classrooms rearrange the desks to suit a group sitting in particular circumstances. For example, the teacher might ask students to sit in groups and doing so necessitates the rearrangement of the desks. Usually this happens when a teacher wants to assign group learning tasks. This arrangement then becomes a temporary arrangement to suit the particular teaching strategy.

Miss McInnis' classroom was different. As I have noted before, the classroom was arranged in groups of tables. This was a permanent arrangement. I came to understand that this kind of arrangement was a way of allowing students to converse with each other about math in the classroom. "I always tell my students that knowledge that you contain in your head is of no use until you explain it to somebody else," Miss McInnis said to me in one of our conversations.

It is not just the classroom arrangement that allowed the students to talk to each other. But Miss McInnis intentionally permitted this to happen in many ways. Earlier I mentioned the noise in Miss McInnis' classroom especially when students were given assignments to do in the class. For many math teachers, especially student teachers, talk in the classroom becomes a discipline issue. Some teachers go to great measures for control. This was not the case with Miss McInnis. Students were allowed to talk, in fact, were encouraged to talk. As I said before, this didn't bother her or the students. They were all relaxed. It would seem to me that this was probably noise to me, but not for Miss McInnis and her students. Miss McInnis behaved in a way that suggested this was not noise at all. It simply was part of the students way of engaging with mathematics and each other.

The nature of tasks and assignments which Miss McInnis gave to her students also promoted student conversations. She used real world examples in presenting or doing math with her students. These illustrations could be from her own experiences or the students' experiences. For example, in one of her classes there was a boy who plays hockey. She used this boy's interest to focus a discussion on probability. She used Wheel of Fortune which was her grandma's show to discuss the uses of statistics. She had one student read from the book while other students listened and discussed with the students what had been read.

Another way in which Miss McInnis promoted student talk about math was through singing with her students. I was able to experience this in one of her classes. In this instance she had just written the homework assignment on the board (figure 2). Explaining that one of the questions involved a grade 7 task, converting a fraction to a decimal, she broke into song (figure 3). The students joined in the singing right away. In

response to a survey question, "What does your teacher do to help you learn mathematics?" several students mentioned the songs.

A fraction is a division
So you don't have to make a decision
You just take the numerator
Divide it by the denominator
And sooner or later
You get a repeater or terminator
'Cause a fraction is a division
So you don't have to make a decision
That's a rap -2 -3- 4
That's a rap!
(Kids do "stomp, stomp, clap")

Fig. 3: Fraction rap (Dave Mitchell)

Trust

It is very normal in math classes for teachers to be worried about whether or not students engage in math tasks. As soon as the teacher assigns tasks to students she will struggle to keep students on their tasks. One might interpret any disengagement as lack of interest in the tasks on the part of students. From this interpretation, one might recommend to the teacher that she/he selects tasks which motivate students.

My experience in Miss McInnis' class shows that this is not a problem for her at all. Previously I had shown how after Miss McInnis had assigned work to students and practically left them to decide what to do, some concentrated on the work; others fluctuated from talking about social life issues and their work. One student decided to finish his project. One boy decided to do nothing. I did not see or hear Miss McInnis telling anybody that you should do your homework. It seemed to me that Miss McInnis trusted her students knew their responsibilities. She left the students to make decisions about the assignments. She attended to students who needed help and moved from table to table recording homework marks. I remember having left Miss McInnis' class the first day curious as to whether some students would actually do the assignment. I was surprised the next day to see that all of the students had done their assignment and more than half of them had done the bonus questions. I was amazed by the way Miss McInnis trusted her students.

Multiple ways of instruction and assessment

In response to a questionnaire question, "What does the teacher do to help your child with mathematics?" one parent answered, "...uses a wide variety of techniques to evaluate and instruct." I also learned that this is what Miss McInnis aims to do in her

teaching and assessment of her students. In one of our conversations, she informed me that she loved the new curriculum and the "Minds on Math" textbook.

> I love the new curriculum and "Minds on Math" textbook. There is more real life, not always dice; more thinking process; more checking of understanding and answers.

Even in the classroom I was able to see the way Miss McInnis used a variety of ways to teach math. Looking back to the example from the beginning of the case we can note that Miss McInnis had organized her teaching of "Making predictions" into four activities (figure 1). First she had students do the activities in their groups and then discuss with them in a large group the next day. On one hand, she seemed like she was reviewing the previous day's assignment, but on the other hand, she was actually teaching about making predictions through different activities and examples through manipulatives; e.g., paper cup and dice; through real life examples; e.g., blood bank and the Wheel of Fortune. Students, too, mentioned a variety of ways Miss McInnis helps them learn math. These included: funny songs, labs, real life examples, stories, phrases and computer games.

In my conversation with Miss McInnis about assessment she had the following to say.

> I believe that kids learn differently. I plan my project assessment tasks to allow kids to use their areas of preference. For example, if someone likes art, then a poster could be an option. For some with an inclination to music, writing math songs could be an option. My aim is to use the subjectivities of students without losing the objective.

Miss McInnis consciously selects questions from the book to assess different abilities. I noticed that whenever she assigns work she will talk about the questions. "Question 3 tests your knowledge of converting fractions to decimals, question 10 application to real life...."

At the time I was visiting, her students were completing a project on statistics. Some had handed it in (see figure 4 for project tasks and sample of student work). Miss McInnis commented to me that the assignment was taken from the text. The project was used to get students to improve the quality of their presentation.

MATH 9-DATA ANALYSIS PROJECT

In this project, you will realize that **presentation** is everything. At the end of this project, you will be able to recognize whether data have been presented in a **misleading** way.

The financial section of the newspaper often shows graphs of economic trends. These graphs often illustrate **distortions**, such as missing portions of the scale on the horizontal or vertical axis. However, don't be led to believe that all statisticians are liars. The science of statistics has benefited us in far more ways than it has misled us. New societal developments (transportation, medicine, and business) often stem from statistical research. (Minds on Math 9, pp. 84–85)

INSTRUCTIONS: In groups of 2–3 students, complete each exercise. Your work should be of top quality. The first couple of exercises are to be presented as a poster. Exercises #3 - 5 are to be written in paragraph form. Anyone seeing your final product should be able to understand the project without seeing this page....make sure your answers are complete!!!

EXERCISE #1: A company sells ice skates, in-line skates and hockey equipment. The table below shows the annual sales for several years. From the information presented in the table, you are to:

Refer to the table 3

a) Draw an honest graph of the data.
b) Draw a graph on p. 84 # which the annual sales do not appear to change very much.
c) Draw a graph that exaggerates the increase in sales.

EXERCISE #2: Look through a magazine or newspaper and find at least one example of a misleading graph. Use the most blatant example, and analyze how it misrepresents the data.

***Misleading statistical statements** are just as common as misleading graphs, if not more so. Use your skills of **critical analysis** to complete the next few exercises.*

EXERCISE #3: Using your favorite magazine, find an article that uses numerical information to reach a conclusion. Analyze the article by answering the following questions:
a) What does the author want you to believe?
b) How do you think the data was collected?
c) Do you think the data is accurate? Why?
d) Do you agree with the author's conclusions?
e) If you were to collect the information, would you do it differently?
f) How could the author use the same data to reach a different conclusion?

EXERCISE #4: Watch a television commercial and answer these questions:
a) What product is being sold?
b) What information or image does the commercial present to persuade you to buy the product?
c) What claims are made?
d) Suppose you wanted to investigate the product on behalf of consumers. What data would you collect? How could you collect the data?
e) What precautions would you take to ensure the data were not biased?

EXERCISE #5: Choose an issue on which you would like to survey the opinions of the other students using one wording of the question, and 10 students using the other wording. Compare the results of the two surveys.
** For this last section, each person is responsible for his/her own paragraph.*

COMMUNICATE: In a short paragraph, answer the following:
a) What did you learn about statistics through this project?
b) What did you enjoy about this project?
c) What difficulties did you experience during this project?

PROJECT DUE DATE:_____
(Late projects=>-10% per day!)

Fig. 4: Minds on Math 9. The project was simply used to get students to improve quality of their presentation.

Care, responsibility, and love

If there is something which came across strongly from parent and student questionnaires about Miss McInnis, it is her responsibility and care for her students. For example, one parent wrote the following, "She's always gone out of her way to help Teddy by coming early in the morning and gives Teddy extra practice. Great with understanding her students." Phrases like "she offers extra help at noon hours and after lunch" were common from parent questionnaires. Students, too, indicated Miss McInnis' care and responsibility for them was important. One student wrote, "she offers classes after school and at lunch. She will take the time to give you personal help. Phones home to let your parents know how you are doing. Gives tips on studying at parent interview. Will recommend tutors or computer math games to make math funny."

In the classroom, in one instance a boy answered a question. Miss McInnis exclaimed "Very good. He is coming back." This was not just an encouragement or reinforcement to the student as one might think. It was genuine happiness. I could see Miss McInnis' face filled with jubilation. This was a real gesture of caring for her students.

On another occasion, she told her students that she was not going to teach them the next day. Although a sub was coming in to teach them, Miss McInnis would come back in the afternoon to help students who had problems with what the other teacher had taught. To me this was another gesture of care and responsibility for the students.

> During our conversations, Miss McInnis' love and caring for her students was reflected in this comment. "Kids need to see that I am human. Laugh with me. Catch me in my mistakes. Talk to me. Sing with me."

In conclusion: Self Reflective

Earlier I mentioned that O'Brien Junior High School supports and encourages teacher's professional development. I came to learn that Miss McInnis was one of the teachers who had taken full advantage of this opportunity. At the time I was visiting her, she shared her portfolio with me. In it I could see how professional development seminars she attended were reflected in her practice. One of the themes she had learned about and become interested in was that of multiple intelligence. From this she had learned that kids differ in their learning. In her portfolio were wonderful examples of student work. In particular one example related to her thinking about multiple intelligence. A booklet about order of operations was done on fabric and meticulously cross stitched. As the previous discussion shows, Miss McInnis is a reflective teacher who takes up opportunities to learn and then make sense of her learning in the context of her classroom. This is manifested in her use of multiple ways of assessment and instruction, her ways of promoting conversations in the classroom, her care, love and trust for her students.

Seven

Chestnut Lane School
"Teamwork For The Benefit Of Others"

Emile Pinco

As I walked into Chestnut Lane School I was greeted by a white board sign on which was written two messages. One was a cheer for the Canadian Olympic Hockey team and the other was a motivational thought of the day. I can't now recall who Canada was playing nor the motivational message, which had changed by my second and third visit, but the message given by this sign was really that there was a sense of community here - a sense that everyone works together. More clearly, too, was the sense of purpose in this school. It may have been the pictures of graduating students on the walls, or perhaps the students busily working in the classroom, or even the fact that there were no adults around to greet me. Where were they? I found the staff room and, as I approached it, a teacher arrived. She may have been on a prep or merely between classes, as I later learned that there are no bells in this school to direct the movement of staff and students. She was walking briskly, carrying a stack of papers. With a cheerful hello, she deposited her load and dashed off, barely having time to point me in the right direction for my observation. People work together as a team here, I thought, not really for individual achievement, but together, for the benefit of others.

The teamwork alluded to in the preceding vignette manifests itself in a number of ways at Chestnut Lane School: The organization and structure of the school and the mathematics class, the interaction in the mathematics class, the expectations of students, and the support from parents and district. What follows is a look at these particular aspects of Chestnut Lane School and how they may contribute to the success of the mathematics program there.

Organization and Structure

Chestnut Lane is a small rural school in central Alberta offering programs for grades one through nine. Most of the classes are split with two grades per classroom teacher; however the grade nine class is never split, even though there are only eleven students this year. This is done intentionally in order to give the grade nines the greatest opportunity to achieve to their potential - another example of teamwork.

Mr. Grant

During the seatwork portion of one of the lessons, Tim Grant, the grade nine teacher at Chestnut Lane School, has an opportunity to come over to talk with me. I have positioned myself in the middle of the classroom, which is, in fact, a science room. Half of the room has the traditional long black tables which are fixed to the floor with sinks, gas and electrical outlets and stools. The other half of the room, where the mathematics lesson is taking place, has desks, roughly arranged in rows; however these have been moved haphazardly throughout the day, likely to accommodate student interaction, as I

learn is the case in Tim's class. My observations, then come from the back of the "mathematics classroom" portion of the room, behind where the students are working.

Tim and I carry on a casual conversation. Both of us continually scan the room, monitoring students as they work, as any teacher feels compelled to do. Students work quietly, occasionally whispering to a neighbor to check some work. I discover that Tim has two young children of his own and that he no longer is able to make the same commitment to extra curricular activities as he once did, yet our discussion reveals that he still puts a significant amount of time and energy into this area. He is curious about the research we are conducting and somewhat puzzled as to what he or the school might be doing differently from other schools which might account for their success on the provincial achievement tests. He feels that that there is nothing really special about what he does, yet as I make my observations I must conclude that there are several factors which I believe contribute to success for his students.

Tim is a relatively new teacher who has been teaching mathematics and physical education at Chestnut Lane since graduating from the University of Alberta six years ago. He teaches in a quiet and relaxed manner and his dry sense of humor is appreciated by his students. "Here are two questions I want you to do for homework so tonight while you're watching Star Trek, punch these into your calculator." His words are combined with a wry smile and a twinkle in his eye. "What is 12 times 12?" There are lots of giggles as students don't seem to know and Tim raises his eyebrows in apparent surprise and disappointment. Quips such as these seem to begin and end every session and, in the nicest sense of the word, Tim will tease a student or even the whole class periodically throughout a lesson.

This type of interaction gave me a sense that this class is really a family within the school community and mathematics is clearly only one aspect of their life here. Before, during and after lesson conversations between Tim and his students include topics such as the upcoming ski trip, incidents which occurred during lunch hour intramurals, and events at students' homes and in the community at large. At one point during a lesson, a bus was heard as it drew up outside of the school. It was not the last class of the day and students wondered out loud as to the purpose of its visit. Many of the students went to the window for a closer look. Tim, himself, hazarded a few guesses, and soon the students were back at work again.

This is, indeed, a family with more than mathematics or even school as the main focus of their lives. Yet, at the same time, the lesson itself is very focused, having a definite structure - homework check, instruction, and seatwork practice leading to homework. In spite of the fact that there is a casualness in approach to learning, both students and teacher work hard throughout the lesson. In none of the lessons which I observed did a discussion go drastically off topic even though Tim punctuated his lessons with subtle humor. Even during seatwork, some students occasionally had short discussions about some personal matter but work would continue throughout their discussion. Rarely did one of these chats last for more than a couple of minutes and if it did, Tim quickly brought them back to task.

If the students were not asking questions, Tim was busy recording the progress of the current lesson or planning the next. He interrupted his administrative tasks

periodically to move around the classroom to monitor and assist the students as necessary. Every so often a student would ask a question out loud and Tim would answer from his workbench. This did not seem to interrupt the other students, perhaps because there were only eleven of them. If the question required a more involved answer, Tim would go over to explain or the student would approach his workbench.

Tim began his lessons by checking that each student had completed the homework assigned and then addressing any questions students may have about it. The student textbooks have answers in them and the students are expected to have their homework already marked. In the lessons which I observed, there were few queries and these were all dealt with thoroughly but quickly. The following exchange took approximately four minutes.

"Any problems with that assignment?" Tim waited a few seconds. "Number 13?" Another few seconds elapsed. "17?" Finally a student says, "18 f." The question asked the students to find the square root of one-ninth. After some exploration with a calculator which involved both Tim and the students, it was found that the answer was one-third. However, Tim pointed out that the question asked for the calculation to be done without a calculator. Students were reminded of the following example:

$$\sqrt{25\times 36} = \sqrt{25}\times\sqrt{36} = 5\times 6 = 30$$

This eventually led the students to the solution as follows:

$$\sqrt{\frac{1}{9}} = \frac{\sqrt{1}}{\sqrt{9}} = \frac{1}{3}$$

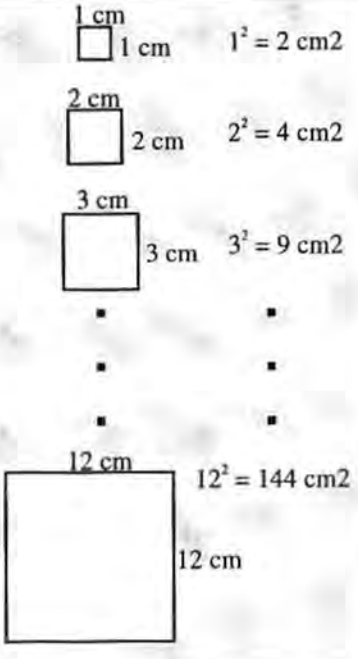
After problems regarding the homework had been addressed, instruction of a new 'lesson' began with Tim writing the objective on the board. For example, "Obj: To describe the meaning of a square root and to estimate a square root." This style continued throughout the lesson with three or four objectives being covered. Through notes, examples, questions, and explanations Tim proceeded to teach this objective.

Tim draws a few squares on the board and asks, "To find the area of these squares we would?"

Students respond by saying "multiply the sides," "base times height" and "one square centimetre."

As the students respond, Tim writes the answers beside each square.

"Now," Tim asks, "What if I had these numbers," pointing to the column of perfect squares (e.g. 144), "and want to find these numbers," pointing to the column of numbers before they were squared (e.g. 122). The students are given a few moments to consider this problem and a couple of them blurt out "take the square root" and then Tim adds, "That's what we're going to be talking about today."



Finally, when the notes and examples were completed and the students had stopped asking for clarification, homework was assigned. A student asked, "Is this for homework?" Tim just smiled and there was general grumbling as the students began. Students spent the last fifteen minutes of the class working on the assignment and Tim moved around assisting them when necessary. Occasionally students would look at other students work or briefly discuss a question, but generally they worked quietly and independently.

High Expectations

One of the reasons which Tim feels may contribute to his students' success is the expectations set for them. He expects his students to work hard and do well and he ensures that they know he wants them to do well. Tim is aware that many students do not like mathematics, but they do like to succeed and he provides every opportunity for them to experience success. For example, he is available after school to help them and students will take advantage of this when they are having difficulty. If students do not take advantage of this service when they need to, Tim will insist that they come for help. Generally, however, he believes his students are comfortable asking for this help.

In the classroom, I noticed that Tim often expected students to try to work things out for themselves before seeking help. "If you're having trouble with a question from this assignment, don't just look up the answer in the back of the book or at your friend's work and write it down. Look in your notes and try to figure it out. If you still can't work it out, put up your hand so I can come and help."

Tim has had most of these students for mathematics since grade 4 and so there's a strong relationship with a lot invested in it. If they are not learning he wants to find out why and do something about it. He knows his students well and they know him and this contributes to the ease with which they can approach him. They know that they are expected to ask questions. He assures his students that it is normal to forget things and he frequently goes back to review concepts. He often says to the students, "There are no dumb questions in math." He told me there is a snowball effect, "When one person asks a question, then others ask."

Tim also builds on students' success with tests. Indeed, during one of my visits there was a surprise quiz. It consisted of eight questions written on the board. Students were not outraged by this as some of my own students might have been. These quizzes obviously occur frequently because students quickly took out some paper and with little instruction began to copy the questions off the board.

The provincial exam is used as part of the final grade for these students and I wonder if the comfort level experienced during these quizzes contributes to the students' success on the provincial test. Reference to the achievement tests was made frequently during my visits and Tim noted that this occurs more during the later part of the year as the exam date approaches. Tim conducts an analyses of the exam making careful note of the areas in which his students performed poorly. These are then addressed with the next year group if any changes are thought to be required.

Outside Support

Tim pointed out that he gets a lot of support from the parents. They, too, have high expectations for their children so they will insist that homework gets completed. If extra help is required after school, there is no question that the students must get it. This is a significant commitment on the parents' part since this is a rural school and transportation arrangements can be difficult at times.

The school board supports the mathematics program at the school by providing in-service opportunities for Tim. There is a modest budget of $100 for professional development and Tim usually attends some workshops, such as those which help to introduce the new curriculum, which he finds extremely helpful. He has found the textbook, MathPower, "OK," but some of the support materials, such as the data management discs, to be unhelpful.

The conversation that I had with the principal revealed that he believes success in the grade nine provincial achievement tests in mathematics is due to the efforts of the entire school community. "We have a strong focus on academics and we have some of the best people. The students get a strong base in grade one and it continues." He believes that their policy of having subject area specialists work with the same children year after year contributes to continuity in the program and expectations of students.

The principal also gives the parents and their children a good deal of credit for the positive learning atmosphere at the school. "The kids are well-behaved, polite and work hard. Not all of them are stars, but their homework gets done. None of them smoke and swearing is not an issue. The mentality of the parents helps too. There is a strong focus on the importance of academics."

The parents obviously support the school and the efforts the teachers are doing and their comments reveal that support. "The teacher takes time with each child, giving them help when needed individually." "He wants them to ask for help and he'll give it to them, even after school." "He makes sure <u>everyone</u> understands." "My child had problems at one time doing some math questions. The teacher worked with my child until my child got the question. That to me is very important. Don't leave the ones that struggle behind." "Attitude towards school in general [is an important factor affecting my child's success in mathematics]. We expect school work to be important."

One parent was more critical. While the parent recognized that individual help was available after school, the parent indicated that the child rarely attended the sessions. "She feels it's not a total worthwhile thing because she always has to wait for him after each question. He leaves in between questions." This parent, too, recognized the importance of student attitude but cautioned that the teacher had a responsibility in this area. "Attitude: hers and his; I also think that children that excel do get the extra attention leaving less for the ones that don't, resulting in an even worse attitude." A further suggestion would be for the teacher to have "a better understanding of how the child feels frustrated with having a hard time learning the math." This was the only dissenting voice.

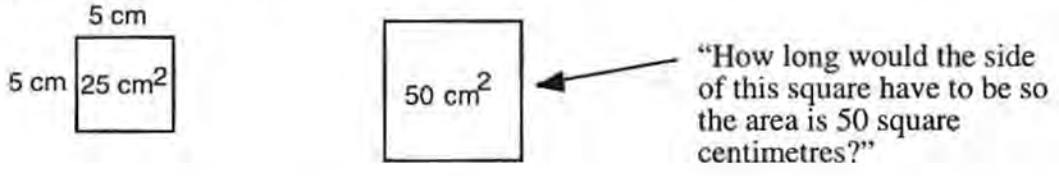
The students, too, recognized and appreciated the work of the teachers. "The teacher asks if there are any problems and allows questions." "He gives me extra work

(help)." "I like how he makes notes and examples about the topic." "He writes objectives on the board." "Stays after school to help us if we need help." "He gives us lots of quizzes."

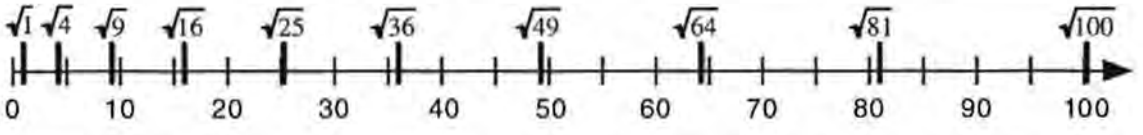
Interaction

One of the most interesting aspects of Tim's lessons was the interaction that occurred between him and the students. As mentioned earlier, there is a strong relationship between them which goes far beyond the mathematics classroom. However, it was the interaction that occurred during the instruction component of the lesson and the extensive nature of it which was most intriguing. These lessons had students very involved in the material. Students were asked questions in such a way as to lead them to see relationships and to form conclusions.

At one point in a lesson, for example, Tim posed the question "If area is doubled, isn't the lengths of the sides doubled?" A couple of students replied "no". Tim said, "Lets try!" and drew two squares on the board.



"It couldn't be 10 because 10 times 10 is a hundred not 50", said one student. Another noted, "It would have to be less than 10 and more than 5." Finally, Tim said "The length of this side is what we have to estimate. Let's try. Everyone take out your ruler." The students each then constructed a number line that could be used to estimate square roots. Tim instructs them, "Go as far as you want, use the whole width of the page. After you draw the line, mark on some perfect squares.



"Notice that the farther up the line you go the farther apart they get. Now, lets do an example. Estimate the square root of 30. 30 is about midway between 25 and 36, which are two perfect roots on our line, so lets guess half way between 5 (the square root of 25) and 6 (the square root of 36). That makes about 5.5. Now take out your calculator and check." After the students checked, they were asked to use their number lines to estimate the square roots of 54 and 23 and use their calculators to compare their estimates.

After this short exercise, which the students caught on to quite quickly, a student queried, "What about really big numbers?" Tim assured the class, "If you want to do larger numbers, you can. All you have to do is make your number line longer, but they won't ask for big numbers on the exam (referring to the provincial exam), say, something like the square root of 2543." This was the only time that Tim made a direct reference to the provincial exam. Of course, the exam does play an important role in much of Tim's

decision making, such as question selection on his own tests and using the exam results as part of the student's final mark.

Throughout Tim's lessons there are many instances of making reference to previously presented material. In a section of the lesson the students were comparing calculating the square root of the product of two numbers with the square root of the sum of the same two numbers.

$\sqrt{25 \times 36}$ and $\sqrt{25 + 36}$

After concluding that 25 x 36 was 900 and that the square root of 900 was 30, Tim posed the question, "Is there another way to figure this out?" One student responded by saying that the root of 25 was 5 and the root of 36 was 6 and so all one had to do was find the product of 5 and 6. "Does this method work for the next one?" After some guessing that it would and further discussion it was soon discovered that it would not work. "Why does it work for multiplication and not for addition?" At this stage it was noticed that some students wanted to answer straight away, but Tim made them wait until others had a chance to "see the question and think about it." Eventually, some of the exponent laws were used to assist students to understand this concept.

These sorts of group exploration activities were common throughout each of the three lessons that I observed and seem to make a significant impact in learning. Parents commented several times that they believed Tim's explanations made a big difference in how well their children did in mathematics. They gave credit for their children's success to "the teacher's method of teaching," his ability "to get the concepts across very well" and "how it is explained." Students appreciated how Tim "relates it to real life", "makes notes and examples about the topic," "explains the questions and asks if we have any questions" and "explains things personally."

From my point of view I got a sense that the students truly benefited from interaction like this. All of the students were attentive throughout the lesson and they were clearly following along. There was a natural dialogue between Tim and the students and at no time was the conversation one-sided. I am certain that Tim knew, as I knew, that students were understanding and he could direct the conversation accordingly.

Teamwork

What is most notable about Chestnut Lane School is the contributions made by everyone to the school. This case study has attempted to illustrate how teamwork manifests itself at Chestnut Lane School. Teamwork is fostered through the school's organization and structure, through the high expectations of the stakeholders, through interaction in the classroom, and through outside support. This is quite an extraordinary combination of conditions for success.

The school, classrooms and lessons at Chestnut Lane School are organized and structured in order to nurture and strengthen teamwork in a very deliberate fashion by all stakeholders. The teacher, in particular, ensures interaction occurs within the mathematics class, has high expectations of his students, and through this is able to obtain the support of others.

Eight

Apple Grove School
"A Tradition of Hard Work"

Emile Pinco

Philosophy versus Practice

Mr. Mullen

While describing the nature of this project to a teacher in the staff room during one of the breaks, I was questioned as to whether it was a teacher's philosophy or her teaching techniques that enabled success. I responded by suggesting that I believed the two were inseparable and that it was likely that the techniques chosen by a teacher were informed by her philosophical stance. Through conversation (interviews and interactions) and observation I came to get a sense of the philosophical position of Ron Mullen, the grade 9 teacher at Apple Grove School. His actions and interactions with staff and students, I believe, are a reflection of his belief in what teaching and learning is and should be and how to engage students in their learning. So while it may be that what Mr. Mullen "says" and "does" attribute directly to student achievement, these actions are informed from a philosophy. Perhaps, then, it is not what a teacher "does" that leads to success, but rather what he "believes". In other words, in determining what makes a successful mathematics program, it is important to look at what a teacher does because of what he believes.

> There are a few moments before class and Ron and I are in the staff room. I am listening to him intently as he is describing his school, his class, what he does - anything and everything that he feels may help me to get some perspective on this successful school. I write furiously, trying not to miss out on any detail which may contribute to this research. *Every time I give a quiz it's because I failed to deliver a good lecture; the quiz gives us a chance to work together to understand the material. . . I don't give homework, it really wasn't getting done and I tried to give detentions but that didn't work. Most of these kids work on farms and with all of their chores they couldn't stay after school and some really didn't have time to do their homework. Anyway, now I end up spending time on things in the next class and I can help at other times during the day. . . Yes, this is real good community. There's no real frustration at home for these kids, pretty stable families."* At that moment a parent pokes her head into the staff room with a bowl of chili for the staff and Ron actually stops in mid sentence to help her out, without excusing himself, completely ignoring me. How rude, I thought for a brief moment until I realized that he sure has a lot of time for parents.

What follows is what I feel is the philosophy which informs the teaching practice of Ron Mullen. This philosophy includes: trust (the preceding conversation took place during the grade 9 science lesson which he teaches), hard work (as seen in this vignette by a willingness to stay after school to give and receive help as well as an awareness of the chores the students do at home),

high expectations (poor performance on a test would not be acceptable and a solution must be found), and collaboration (Mr. Mullen accepts partial responsibility for students doing poorly and helps students meet expectations; also, the parents important role in the school and their many contributions to the schools' success).

The setting

Apple Grove School is a small rural elementary-junior high school in central Alberta. Although the school building is old at 41 years, it is well maintained and includes an excellent up to date computer lab. The atmosphere is of a happy place for students. There are numerous pictures of graduates going far back to the early years when it was also a high school. Displays on the walls along the corridors show off student work and there are thank-you cards in the staff room expressing appreciation for the welcome received by a new family and for the hard work by staff at a weekend activity. The members of this community are confident and proud of their school.

There are about 180 students at Apple Grove School, 22 of whom are in grade 9. The students come predominantly from a farming background. Based on the parents' surveys, it appears the families are long-time residents in the community (same residence for at least three years). The surveys also show that most parents had some post-secondary education and had a combined family income in excess of $40 000[1] . The responses to the questionnaire suggest that many of the parents hold similar values and expectations with respect to their children's mathematics education.

Ron Mullen, the Grade 9 math and science teacher is also the principal of Apple Grove and has been teaching for over 25 years. He provided a warm reception upon my arrival, obviously delighted to have had his school chosen to participate in the project. Although pleased, Mr. Mullen was not surprised at being selected, knowing full well of his students excellent performance in the past and how this has contributed to his school's good reputation in the surrounding community.

The grade nine classroom is unremarkable, really. Desks are in rows and there are posters and charts on the walls as well as samples of student work. The back corner bulletin board has a mathematics focus with information about mathematics contests, calculators and there are folders containing "Challenge Problems." With the introduction of the new curriculum, however, these problem-solving activities no longer play as big a role as they once did in Mr. Mullen's lessons.

The lesson structure

The structure of Mr. Mullen's lessons is usually comprised of two components: an instructional component and a seatwork component. The instructional component of the lessons that I observed consisted of discussing the questions of a test that was handed back and an interactive lecture/discussion of a mathematical concept, solving similar triangles in this case.

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[1] There were 15 respondents to the parent questionnaire out of the 22 possible, but only ten responded to the question on family income.

"OK, everyone, you see the diagram on page 219? Can we draw two triangles?" General agreement. *"Ok, separate the two triangles, draw them and label them."* Ron waits a few moments and begins going up and down the rows checking each student's diagrams, assisting one here, complimenting one there, joking with another. *"You might want to draw two triangles, can you see two? . . . That's good work, Jen, keep going. . . You looked like a big chipmunk at lunch, Brad. How many marshmallows did you get in your mouth?"* As the class proceeds through the question, Ron moves around the classroom again and again, checking each student's work, ensuring each is following along and coming to better understand similarity.

The instructional component, which in this case involved a discussion and student-worked examples, was seen to take other forms. For example, the 'pop quiz', which one student noted helps him learn mathematics, is an interesting activity because of the way Mr. Mullen used it. It could be considered to be part of the instructional component. While writing the test, the students asked for clarification about certain questions and Mr. Mullen was certainly not averse to giving 'hints' as to how to approach specific questions - a teachable moment, one might say. Later, addressing student difficulties on the test after it had been marked was another way Mr. Mullen further developed certain concepts with his students.

Testing students certainly gives feedback to the teacher as to student progress, but it is also a chance for students to practice recently learned material and for teachers to provide instruction. Interestingly, Mr. Mullen's comments during the test were a source of encouragement for the students. The comments assisted some students to persevere with a difficult question or complimented others for completing something challenging. "Yeah, that's a hard question, but think about what we did in class ... look at this part of the diagram ... Hey, good job on that question!" After the test was corrected Mr. Mullen again recognized good work and provided praise. "Congratulations! The first question was quite difficult but most of you got it right. Some people even answered it in a way I never thought of." This kind of encouragement and praise, I believe, provides students with valuable test taking strategies. They learned to think back to class when facing a difficult question, and learned that they can answer tough questions in interesting ways. Moreover, the students were practicing writing for the final exam and performing under pressure. Indeed, during the quiz Mr. Mullen said, "To make this a valid Grade 9 exam experience, you have eight minutes left."

Whereas, it could be said that the instructional component of the lesson is where the students 'learn' the material, the seatwork, on the other hand, is in essence the part of the lesson where the students 'practice' what they have learned. From my observations, this latter component consisted of selected questions assigned from the textbook, "Minds On Math"[2] and, as stated, the pop quiz. Both components mentioned were not part of every one of Mr. Mullen's lessons. Sometimes a "lesson" might take more than one class period. For example, during my last observation class, the entire period was spent on seatwork that was assigned in the previous lesson and most of that previous lesson consisted of the instructional component.

[2] Mr. Mullen has some reservations about this specific textbook. In particular he questioned its readability for the average grade nine student and the order in which some of the concepts are presented.

Trust

The twenty-one students who comprise the class are generally well behaved and obviously trusted. Mr. Mullen confidently leaves them unattended doing their seatwork, which occurs not infrequently because of his position as principal. Having said this, when Mr. Mullen is in class I observed him to monitor students remarkably closely, checking their work individually several times throughout a class. During an instruction component of the lesson, for instance, he gave the students a task (complete a question, draw a diagram, etc.). He then proceeded to look at every student's work. When he noticed that students were not pulling their weight, he would stop what he had been doing in order to impress upon them their responsibilities. "This is pretty sloppy, Darren. Why don't you erase it and use a ruler. An examiner isn't going to be able to give you marks if he can't read anything."

Maintaining this trusting relationship was evident when just before my first classroom visit, Mr. Mullen said to me, "I have to apologize, yesterday we got a little bogged down." Apparently, some students were abusing the system somewhat. Since there are answers in the back of the textbook students are shown how to use them and encouraged to do so. This time, however, some students wrote "answers" without work and couldn't explain how they had obtained the answers. A "pop" quiz would therefore be administered in this next class I was to observe. Quizzes such as these, as I have already indicated, provide opportunities for instruction of content and test taking strategies, practice, evaluation of student progress, and motivation. The notion is that if students performed poorly on a pop quiz they would more likely concentrate during future lessons and assignments as well as ask questions if they did not understand some of the material. Not knowing if a quiz would be given would keep students on their toes. In this case, specifically, the quiz would help to ensure that students would use the answers in the back of the textbook more honestly. The questions on this test covered material presented in the previous lesson and students did not seem overly surprised when Mr. Mullen announced it.

Hard work

There is a tradition of hard work at Apple Grove School and one of Mr. Mullen's beliefs is the value of hard work. Teachers work very hard and as Mr. Mullen notes "you have to do lots of everything" in a small rural school.

On several occasions he remarked how instrumental the rest of the school community was in the success of grade nine students in mathematics. "Their success is due to success in the lower grades and the whole program." Indeed, on the staff room walls there are charts showing the entire curriculum from grade one through nine broken down by concept, showing which concepts would be taught in which month. This gave teachers the opportunity to ensure that students were well prepared for the next grade level since it could be clearly seen what students would be doing in the following year. This is particularly important for the elementary teachers because it stresses the fact that what a teacher does in grade one truly affects performance in grade nine. Additionally, this type of articulation assists in cross curricular work, ensuring that particular mathematics concepts that are required for science, for instance, are taught early enough in the school year.

Mr. Mullen also provides a tremendous amount of individualization. Student comments also indicate that they recognize and appreciate the individual help Mr. Mullen is able to provide not only during class time but also at lunch time and after school. They commented: "he helps

us at noon," "he provides additional help if needed both during and after classes," "if you have trouble he helps you" and "he sits beside our desk if needed." As mentioned earlier, Mr. Mullen is constantly moving around the classroom checking students' work, both during his "instructional" component and during seatwork. During the "pop quiz", he told a few of the students who were absent which particular questions would not count for marks. He emphasized to them, however, that they should make every attempt to answer the question as best they could and that he would help them with the question later. During the next lesson, while passing the quizzes back to the students, I noted that those students who had not done well on the test had already been seen during the lunch break and their specific problems were addressed at that time.

Individualization was witnessed in another way. There was a student who, because of a personal/family situation, had recently moved to Apple Grove. This student clearly had difficulty focusing on the lesson and Mr. Mullen seemed to make a concerted effort to assist and motivate her during the seatwork component. Although I am uncertain as to whether Mr. Mullen has set up a modified program for her, I have no doubt that it would be provided if required.

One point that remains a curiosity is the absence of assigned mathematics homework. Although Mr. Mullen works extremely hard and instills a sound work ethic in his students he chooses only on the very rare occasion to assign homework. He says that in the past many students were coming to school with their assignments not done, primarily because of their commitments on the family farms. It must also be noted that class time is very productive and there are very few wasted minutes during a lesson. From the student questionnaires I learned that many students, in fact, do mathematics work at home. It was not clear from my observations why that was the case since Mr. Mullen has a policy of generally not assigning homework. Could it be that he assigns more than he realizes? Or perhaps, it may be that the students themselves feel an obligation to do work at home when they are experiencing difficulty. This obligation may manifest itself because of what Mr. Mullen says and does during a class. In other words, if someone, such as your teacher, works hard, you feel obliged to work hard too. Still, it may be that the students do mathematics work at home because their parents insist on it. It has been said that this is a community which values hard work and education and while Mr. Mullen may not assign any specific mathematics homework, parents may well demand extra study from their children.

High expectations

The students of Apple Grove School have high expectations placed on them from many areas. From Mr. Mullen and their parents for sure, but also from themselves and their personal family and school history. In response to a question from the Student Questionnaire, "Do you think you will be well prepared for [the provincial mathematics achievement exam]?" all but one responded "yes." In response to question 11, "How do you feel about the [exam]?" all but three sounded either ambivalent or positive with comments such as "I don't mind", "It's just another test", "I know my math so I should do fine", "Does not bother me", "I'm comfortable with it", "not worried", "confident." Parent comments, too, indicate that they expect their children to perform well on the provincial exam and they generally express the view that it is because of the hard work on the part of their children and the teacher.

Mr. Mullen, during my interview with him, mentioned that he believes all of his students can do well and that he "teaches for success." The students also appear to sense that Mr. Mullen

will go a long way to help them learn. Comments on several questionnaires expressed an appreciation for Mr. Mullen's persistence in explaining concepts. As one student said, he will explain it "a million times 'til everyone understands how to do it." And as mentioned earlier, this often occurs outside of regular class time.

Mary is sitting quietly in the last desk of the end row. It seems obvious to me that she is not focused on the lesson. She looks around nervously, pretending to take notes and during the assignment is not working at all, continuing the charade. Mr. Mullen moves around the class working with the students and eventually reaches her desk, as she knew he would. I can barely hear what they are discussing. I discover later that Mary has recently moved to the area and is new to the school. There are family problems and she is living with relatives for the time being. She can't see much point in doing mathematics. Ron is trying to persuade her to get to work and is being very persistent. Mary is very reluctant but after about 5 or 6 minutes she begins to work. Soon after he goes to work with other students she becomes distracted once again. Ron, however, is extremely understanding and would have to return many times to continue to cajole her to work. He refuses to give up.

Collaboration

The Parent Community

As has been hinted throughout this case study, parents play a very significant role in their children's success. This was evident through my observations and then articulated by Mr. Mullen during my interview with him. He frequently gave credit to a hard-working parent community committed to education. "Our community believes education will make a difference. They take things seriously."

Interestingly, while a few of the parent responses to the questionnaire indicated that hard work on the students' part was the biggest difference as to how well their child does in mathematics, the majority of parents cited the teacher, his explanations and willingness to offer extra help as the reason for success. Furthermore, several parents attributed their child's success to the overall education program at the school and in particular to all of the teachers.

A Focus on the Test

Exam performance is an important indicator of success at Apple Grove School and as a result, tests provide the major part of a student's grade. In fact 45% of the student's course grade is based on final examinations (half from the provincial exam and half from a teacher-made final exam). Certainly Mr. Mullen teaches towards the provincial exam and asserts that it is his duty to do so because exam results are published and they are a reflection on his school. On several occasions during my observation I noticed that Mr. Mullen made reference to the provincial exam: "You must show your work or the province won't give you any marks. . . .You have to do

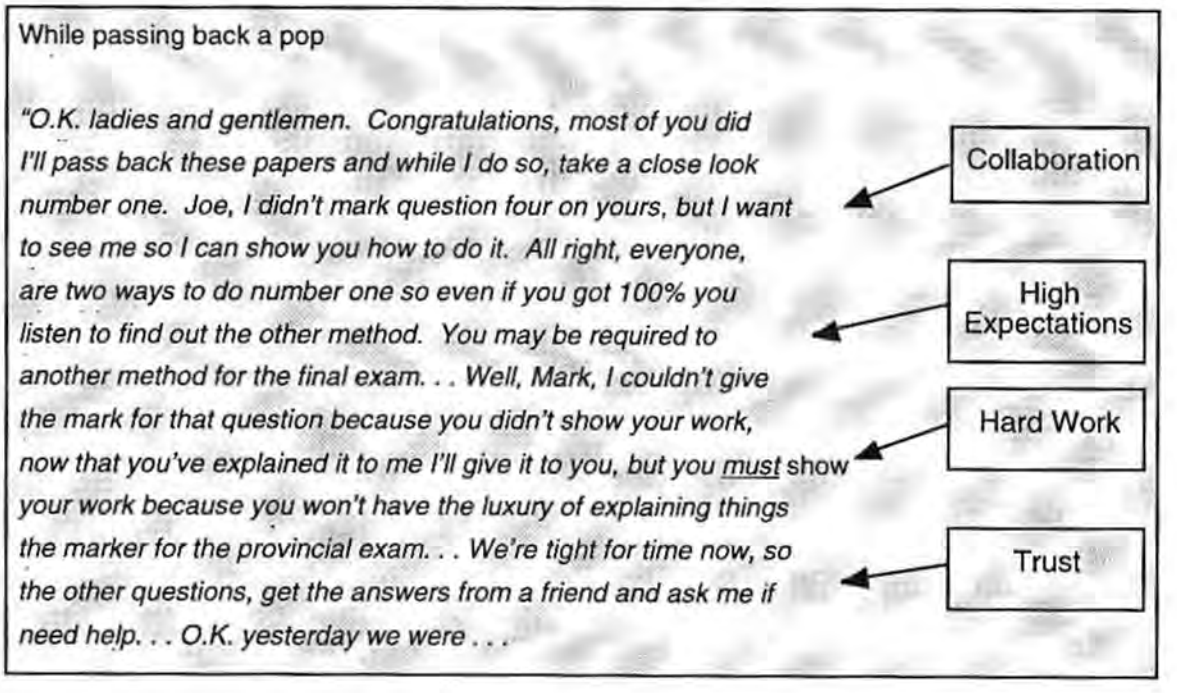
the questions the province's way or you will be marked wrong." ... "You've got the idea, now let's see the mathematical jargon that the province uses." He also mentioned during the interview that as the final exam date approaches the style of his exams changes to match the style of the government exam.

Because the test results are important to Mr. Mullen and because he really cares about how his students perform, he and the students, in effect become partners - collaborators for success on the provincial exam. "I'm on your side to beat this." He doesn't teach so "the student" will pass, he teaches so "we" can pass. Mr. Mullen believes that his role as a teacher is to be a partner in the students' learning. He feels that "together, the students and I will be successful on the exam."

One of the ways he tries to convey this message is by giving students a "pre-test" and then a test of a similar format. The pre-test is open book and students can work with each other and ask the teacher for help. Mr. Mullen believes that all of this contributes to an anticipation of success by the students and they will work hard to achieve it.

The whole package

Interestingly, when asked about making recommendations to a fellow principal about supporting mathematics learning, Mr. Mullen said that the question was looking for a simplistic answer when there is "not a single thing that makes the program work." He felt that it was the whole package that enabled success: a strong work ethic, a committed staff, a supportive parent community, and an expectation of success. I suspect it is this and more - it is one's philosophy and in Mr. Mullen's case this includes trust, hard work, high expectations, and collaboration.


While passing back a pop
"O.K. ladies and gentlemen. Congratulations, most of you did
I'll pass back these papers and while I do so, take a close look
number one. Joe, I didn't mark question four on yours, but I want
to see me so I can show you how to do it. All right, everyone,
are two ways to do number one so even if you got 100% you
listen to find out the other method. You may be required to
another method for the final exam. . . Well, Mark, I couldn't give
the mark for that question because you didn't show your work,
now that you've explained it to me I'll give it to you, but you must show
your work because you won't have the luxury of explaining things
the marker for the provincial exam. . . We're tight for time now, so
the other questions, get the answers from a friend and ask me if
need help. . . O.K. yesterday we were . . .
Collaboration
High Expectations
Hard Work
Trust

Nine

Birch Tree School

"A Caring Approach To Learning Mathematics"

Emile Pinco

Mr. Hilyar

Steve Hilyar is both the mathematics teacher and the recent principal of Birch Tree School, a grade 1 - 9 school situated within the town limits of Dackville. This town is surrounded by some of Alberta's best agricultural production, has a population of approximately 14 000 and its immediate trading area has a population of about 60 000. Although located in town, the school draws 80% of its 259 students from the surrounding community. Birch Tree had been a part of a rural school division before recent district reorganizations within Alberta and continues to draw the majority of its students from the rural area.

Because of recent renovations, I was surprised to learn that the school building is approximately 40 years old. It has been completely remodeled from the carpet to the light fixtures, with new large windows providing a bright environment. The staff room and the office areas are newly furnished. The entrance to the office made me feel that I was entering a well organized and efficiently run school. The secretary was cheerful as she worked busily, and continued to work as she greeted me. She had been expecting me and directed me to the staff room where I was instructed to wait for Mr. Hilyar.

Steve Hilyar has been the grade 9 mathematics teacher at Birch Tree for the past 8 years. The class this year is unusually small with 19 students enrolled. Normally, enrollment is nearer 30 students. Mathematics is not held in the same room for every class and Mr. Hilyar makes no special arrangements with either desks or student seating. The lessons are organized first with an introduction and the taking up of homework difficulties, then instruction of a new concept, and finally seatwork which becomes homework if not completed by the end of the lesson.

Atmosphere

One of the most interesting features of Birch Tree School is its atmosphere. One gets a feeling that this is a school filled with caring and conscientious staff who are trying to teach children to be responsible and hard-working citizens. At one point, while walking back from one of my observations, I noticed some students were clearing up some mess on the floor. The young students, who were in the upper elementary age group, had a bucket and a mop and were supervised by a teacher working in the classroom. One of the students accidentally backed up and knocked the bucket of water over. The supervising teacher came out and very matter-of-factly exclaimed, "Whoops!", and proceeded to help the students move items that were nearby that were about to get wet. Another teacher passed by and grabbed the mop and started clearing away the spill. In a very real way, these two teachers were giving clear messages to students that it's okay to make mistakes, and that people ought to help each other. As one parent put it, "The school seems to take time, to care!"

As I sat down in the staff room I decided that I would start writing one of my case studies since I was very early. I was between schools and simply had to wait for my next observation, which was after lunch. I only just got started when the lunch break began and so I took the opportunity to meet some of the other staff members. I was struck by the happy atmosphere as people began coming in. Throughout my visit the previous day I had witnessed everyone working hard, including the support staff, and yet I did not sense, especially now, that anyone was overworked, although I am sure they might disagree. I briefly met a teacher's aid who had recently been transferred to the school and she described her work load. While she felt that she worked hard she also said she loved it. A couple of student teachers also came into the staff room during this time and flopped down with a "Phew." They commented that their round was nearly complete and noted how quickly it went by. "It sure is hard work, but it was also a lot of fun." The collegial atmosphere in the staff room

This comfortable blend of seriousness and casualness is a feature of the mathematics classrooms that I observed as well. While Mr. Hilyar is certainly serious about mathematics and learning, he portrays himself in a somewhat casual manner both with respect to his natural approach in the classroom and his appearance (he doesn't wear a tie, for instance). This combination of characteristics likely makes him very approachable. In the classroom, for example, students were not apprehensive about either answering or asking questions. Even when confronted about some garbage left after lunch, the students responsible quickly came forward and cleared away the mess. This approachability was recognized by students in their responses to the questionnaire. "If you have questions in class you can ask for help." "He helps me in my spare time." "He answers questions we have about last nights' homework." "He's always there to help me during math class."

Comments from the six returned parent questionnaires also acknowledged their children's comfort in approaching Mr. Hilyar for help. "He listens and respects their questions." "If he is having problems, he knows he can ask the teacher and he is always willing to explain it out." "The teacher explains things with an interest in the students' learning it all."

Crediting Others for Success

The community atmosphere of caring and helping can also be seen when members of this school community gave their views on why the mathematics program at Birch Tree School is so successful. There were many similarities in the views expressed but there was something particularly interesting about all of their responses. Each did not take credit for the success of the program. The principal/teacher, for example, described his staff as being hardworking, praised the parent community as being very supportive, and acknowledged the students as "good kids who take it seriously." He also gave credit to a supportive central office.

The parents, however, praised the school in general and the hard work of staff as contributing to the school's success. They also credit Mr. Hilyar in particular for his commitment to the school. They appreciated his ability to listen and respect their children's difficulties as well as the notes, examples, and explanations he provided them. They noted and approved his policies for ensuring students work hard, such as the contact he made with them and the frequent quizzes. The parents also commended their children's maturity for taking responsibility for their own learning, crediting this, too, as significant in the program's success.

The students, from their perspective, primarily felt the success of the program was due to their mathematics teacher. They appreciated Mr. Hilyar's notes, examples, and explanations, as well as his accessibility for extra help and attributed their success to these factors. It seems that no one felt that they themselves were the major contributors to success in mathematics achievement at Birch Tree School. I feel that, in some way, this attitude contributes to the atmosphere of caring in this school.

The Provincial Achievement Tests

Steve Hilyar also acknowledged the support received from central office. There is a Deputy Superintendent in charge of curriculum who places a high emphasis on achievement results. Schools that perform well are publicly recognized by the board. The board also supports professional development through workshops and relief time to observe and meet with other mathematics teachers. He believes that these sorts of things also lead to success on the provincial achievement tests.

The results of the provincial achievement tests certainly play an important role in the educational decisions that occur in the mathematics program at Birch Tree School. The students are well aware that there is an achievement test at the end of grade nine and that results of this exam will be included on their final grade. The results of the tests are examined very closely and the school is extremely proud of the results, which are thoroughly discussed and analyzed.

The results of the exam also shed some light on the philosophical position of Mr. Hilyar towards teaching mathematics. He treats the test like a goal and throughout our discussions made references to achievement on the test as a shared responsibility. "We want to achieve", "I want to help them achieve" are typical phrases used to describe the collaborative effort he feels is required to achieve success.

Yet, Mr. Hilyar realizes that not every student can achieve excellence on the exam, and this is certainly not expected. In a very caring way, however, students are expected to work hard and seriously try to achieve to the best of their abilities. This is generally accomplished by building confidence, by convincing students that they can achieve.

Jared is a tall, heavy set boy who sits at the back of a side row of desks. I am impressed by his concentration. He had come a few minutes late for class, but he entered the room so quietly I almost didn't notice. He quickly took out his books and followed the rest of the class, listening and taking notes. During the seatwork portion of the lesson, Jared would ask Mr. Hilyar or the student in front of him questions.

Later I commented to Mr. Hilyar on the fact that Jared worked very hard and that he must be doing well. Mr. Hilyar responded that in fact Jared has a difficult time with mathematics and often gets extra help. Mr. Hilyar also modifies some of the assignments for Jared. "He has responded so well to this. Before this he was quite aggressive and often didn't do any work at all."

One final note: Mr. Hilyar will tell students that it's "OK not to do well" as long as they have done their best. Using the phrase "I don't understand," however, is unacceptable. There is an informal policy students have to do their work; they cannot choose not to do their work. Mr. Hilyar has a very close relationship to his students and he provides help immediately if they're experiencing frustration. In their responses to the questionnaire, both students and parents noted their appreciation for this individual assistance which occurs during class time, before and after school and during lunch. "He takes you in at lunch for extra help." "He helps me in his spare time." "He spends extra time with my child."

The provincial achievement test is designed around the Alberta Program of Studies and Mr. Hilyar indicated that the staff pays close attention to this document. This point was reiterated a number of times. For instance, he mentioned that he (as the principal) tries to ensure that teachers are following the program of studies through normal evaluation procedures. Mr. Hilyar also believes that it is essential to have a qualified and experienced mathematics specialist on staff who has "the know-how to teach math." He feels that it would be detrimental to the program if a teacher simply took the teaching assignment "because there is less marking." Mr. Hilyar had nothing but praise for all of his staff who each, from the grade one to the grade nine teacher, contributed in his/her own way to the success of the grade nine mathematics program.

Interaction in the Classroom

One of the most remarkable aspects of Mr. Hilyar's lessons was the amount of interaction that occurred. While discussing one problem that students had difficulty with from the homework, at least half of the class responded to questions posed to them. The questions ranged from ones requiring single word responses to those calling for more thorough and elaborate explanations. Addressing this one particular problem took a full 8 minutes and included a review of the unit to that point. Following is a list of some of the questions posed during this segment.

Mr. Hilyar: "Any questions from the homework?"

Student: Number twenty-four k.

$$\frac{5^2}{5^0} \times \frac{5^{-1}}{5^3}$$

"Can you explain what you did?"

"Okay, Kevin, how do we divide to get 5^2?"

"Where are students likely to make mistakes?"

"How do we do these, five to the ...?"

"What do we do when we multiply with the same bases?"

"Why?"

"What would we do if the question asked us to write it with positive exponents?"

"It says 'Explain your answer.' Carol, can you explain it?"

"Let's review the laws we have so far. Duane?"

"To write as powers, Phil, what would I get?"

"What does this mean?"

"Without using expanded form, can anyone guess what the power answer will be?"

As can be noted, some of the questions require one word responses, some require a short phrase, and some will require a longer response. These, especially, help students to understand more meaningfully the mathematical concepts. However it must be said that while many of the questions simply required short responses, the whole development of the theme was done in a meaningful way.

The class has been developing some of the laws of exponents and have just completed a few examples of the power of a power rule.

e.g. $(3^5)^4$ The teacher asks, "What's the answer?"

A student responds, "3^{20}."

"Explain how you did that, Ron."

"Well, I just multiplied the five and the four to get twenty."

"Why does that work?"

"Cause you have four 'three to the power of fives,' so really you are just multiplying with the same base so you add exponents. Adding five 'four times' is the same as multiplying five times four."

"Good, yes Ali."

"What happens if you have like $\left(\frac{2^3}{3}\right)^6$?"

"O.K., good question. It's a little bit beyond what we have to do but its an interesting question so we'll do it. Barb, how would you do it?"

I don't know, K, maybe you can put it a whole bunch of times, like you did before."

"Gord, can you help?"

"Two thirds to the eighteenth?"

"How did you get that?"

"I just multiplied the three and the six, won't that work?"

"How could we check that, Nick?"

"Do it the long way, you know, put what's in the brackets six times."

$\left(\frac{2^3}{3}\right)\left(\frac{2^3}{3}\right)\left(\frac{2^3}{3}\right)\left(\frac{2^3}{3}\right)\left(\frac{2^3}{3}\right)\left(\frac{2^3}{3}\right)$, "OK, now what?"

"Just add up all the threes."

"What about all the threes in the denominator?"

There is silence, until a student blurts out, "They have exponent one so you have to add those ones."

"Ahh, so what do you get now?"

"Two to the power of eighteen over three to the power of six."

"Yeah, that's right, does everyone see that?" Mr. Hilyar repeats the explanation this time pointing to the numbers on the board. The students seem satisfied. "Well, it looks like we're ready to try some..."

The interaction between teacher and students is not restricted to the "instructional" component of the lesson. Throughout the seatwork portion of the lesson Mr. Hilyar would be walking around to assist students; checking how they were doing, asking and answering questions, and occasionally stopping the entire class to clarify a point. Furthermore, there was interaction between students and this was certainly allowed to take place. There were many instances where one student would consult with another to assist with a question or simply to check a solution. One might conclude that earlier on in the year students were encouraged to work with each other.

The Textbook

The textbook[1] was an interesting source of mathematics for Mr. Hilyar and his students. Although the textbook was used extensively, Mr. Hilyar has some reservations about its usefulness. During my interview with him, he mentioned that the language used throughout the book was quite difficult for a lot of the students. He also noted that in many instances he preferred to introduce topics in a different order than the text presents them. "I sometimes can't quite figure out what the book is trying to do. Maybe they're trying to challenge the students at times, but they seem to ask questions about a topic that hasn't been covered yet."

Mr. Hilyar was even critical of the order in which the questions appeared in the exercises. In one particular lesson when Mr. Hilyar was assigning seatwork, he wrote the assignment as follows: page 288 #6, 10, 12 - 17 odd, then 7, 8 odd. It was made very clear to the students that

they were to attempt the questions from this page in this order and that it was very important to do so. The students trusted and appreciated Mr. Hilyar's advice that it would be better for them and that the assignment would be easier for them and they would understand things better if they did so. Mr. Hilyar was always open about his criticism of the textbook to the students.

Mr. Hilyar:	"Any questions from the homework?"
Joey:	"Number twenty-one."
	Use your calculator to work out $2^{-3} \times 2^{-5}$. Explain your answer.
Mr. Hilyar:	"I don't like this question because it involves using a calculator." "Joey, look at 2^{-3}. How would you figure that out?"
Joey:	"I don't know."
Mr. Hilyar:	"Karen, can you help him?"
Karen:	"First flip it, then two to the third is eight, so you get one eighth."
Mr. Hilyar:	"Good, so Joey, how would I do 2^{-5}?"
Karen:	"You have to flip it over."
Mr. Hilyar:	"Right, then what?"
Joey:	"One over two to the fifth."
Mr. Hilyar:	"OK. Which is 1 over thirty-two. Now what's one eighth times 1 over thirty-two?"
Joey:	"I don't know."
Mr. Hilyar:	"Do you remember how to multiply fractions?"
Joey:	"Oh yeah! Multiply the bottoms."
Mr. Hilyar:	"Good, so you get...?"
Joey:	"256."
Mr. Hilyar:	"Now, using your calculator, do you know how to punch in 2^{-3}?"
Joey:	"Yeah."

Mr. Hilyar:	"What do you get?"
Joey:	"0.125"
Mr. Hilyar:	"Now multiply that with 2^{-5}. What do you get?"
Joey:	"0.0039062"
Mr. Hilyar:	"And now if you work out 1 over 256 you should get the same thing."
Joey:	"I got 3.9062 -3."
Mr. Hilyar:	"That's the same thing, only in scientific notation. That's why I don't like this question, because everyone's calculator works differently."
Ron:	"You haven't finished. It also says explain your answer."
Mr. Hilyar:	"Shelly, can you explain it?"
Shelly:	"Well, when you do it this way, using our laws of exponents, you get 1 over 256, which works out to 0.0039052."
Ron:	"That's it? That's all you have to put?"
Mr. Hilyar:	"That's it!"

One final aspect about the use of the textbook is the use of the answers in the back. Students are encouraged to use them and Mr. Hilyar commented that checking the answers in the back is like shooting at a target. "Without looking at how one has done after each shot, it is impossible to know how to adjust your aim. Checking answers in the back of the text is really the same thing. Students need to know if they are doing the questions correctly." He also believes it to be a valuable way of teaching responsibility; for students to be accountable for their own learning.

Parent Community

Steve Hilyar acknowledges the support of the parent community who he described as "a homogeneous group with a good socioeconomic status." This is confirmed by the parent questionnaires which indicated that combined family income was greater than $20 000 for all parents who responded[1] and greater than $40 000 for half of the respondents. The Economic Development Coordinator of the town of Dackville makes the claim that "Our non-union labor force is made up mainly of rural non-transient young people already instilled with a solid work ethic." Most of the parents had completed high school or university and lived in the area for at least two years.

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[3] Six of 17 parents responded, four of the six responded to the question regarding income.

All parents indicated that they were supportive of the school and the efforts of the teacher. They had high expectations of both the school and their children and anticipated success on the provincial exam. "My child will be well prepared for the provincial exam because he will study." "I believe my child knows the importance of doing well and therefore will study for the exam." "She will do well, she has been successful so far." "He was well prepared for grade nine."

Parent communication is encouraged at Birch Tree School and parents are informed if students are not doing well. Mr. Hilyar notes, "The parents view education as extremely important." If a student is experiencing difficulty the parents are contacted and they are very cooperative about allowing students to stay after school for help and for ensuring extra work is completed.

A Place of Caring

Birch Tree School has been described as a caring school. Every member of the school community extends a helping hand in the success of the school. This was evident in a number of areas. Through their actions, an atmosphere of caring is created by the staff. It is as if teaching is their calling and they seem to enjoy working hard to help others. In a unique way, each of the members of this community cares and credits others for the school's success. Each seems to work hard to make a contribution and it is together through everyone's efforts that the school thrives—parents credit the teachers and their children; teachers credit parents, children, and support staff; students credit teachers.

Steve Hilyar, in particular, is approachable and this is highly appreciated by parents and students. Mr. Hilyar also promotes participation and interaction within his classroom. Through his questioning techniques, he enables students to think meaningfully about mathematical concepts. In a caring manner, he encourages students to interact with each other as well. His thoughtful use of the textbook in his lessons and the provincial achievement test as a motivator for students illustrates how students are central in his decision making.

Through a caring approach, Birch Tree School has consistently enabled its students to obtain outstanding achievement on the mathematics provincial achievement tests.

Ten

Bellcroft

Learning community: a place for everyone to learn and grow

Joyce Mgombelo

Shannon Sookochoff

Mr. Jack Flynn and Mr. John Chieng teach mathematics at Bellcroft School, a junior high with a population of 728 students located in one of Alberta's largest urban school districts. There, they have earned the confidence of students, parents, the principal, the district, and the mathematics education community.

Staff at Bellcroft School are quick to point out that they draw from a community poised to support education and that the achievement the school has enjoyed is largely due to the population it serves. The principal admits that strategies which succeed at Bellcroft would not necessarily work at an inner city school. The school is tailored to suit this particular middle class community. Our parent survey indicates that nearly 90% of the students come from families where at least one parent has some post secondary education. Almost half of those students have a mother and a father who have both completed a post secondary program. Seeming to understand the importance of a good role model as a beacon to her son, one mother clarified that although the child's father had completed "some high school," the stepfather had completed a post secondary program. She further writes that this stepfather is the boy's "in-home example." Further, two thirds of the respondents to our parent survey have lived at their current address for more than three years. One third have an combined family income between $40 000 and $60 000. Another third of the families earn more than $60 000.

Success according to parents at Bellcroft School

Parents had a lot to say about the definition of success for their child. Many mentioned overcoming math anxiety and feeling good about math. One parent feels strongly about what would help her son feel successful.

> I think that my son feels more successful, in <u>his</u> mind, whenever he increases his marks. However, in <u>my</u> opinion, success, especially in math, means overcoming the fear over the math and the concepts which seem difficult to grasp. Once the fear is gone, the child's ability will grow.
>
> I think that more one to one work on solving math problems could help children free themselves from their fear. Also applying math concepts to students' everyday lives and making the math look more real than abstract, would make it easier to understand.
>
> Or, for example, helping children understand how (a^2-b^2) is $(a-b)(a+b)$. Or, the math concept at work in a machine or in building something. Anything that could help a math concept have a more real meaning, a meaning outside of our heads.

It is significant to us that this mother replied to our questionnaire in such detail. Her views on the importance of math anxiety speak to this community's concern for the welfare of children over their test achievement. Judging from her specific example, a difference of squares, she seems to have a sense of what an understanding of mathematics can be. If this mother is any indication, Bellcroft School draws from a pool of parents who can see beyond measuring achievement simply by quantitative measures to the richer knowing that occurs when students and teachers take time together and when mathematics reaches beyond its abstract existence into the concrete lives of children and the practical world. Such an astute parent group would surely have an influence on achievement.

The principal talks about success

Interestingly, the principal, Gerry Woodman, explains that although one of the school's goals relates to results on the achievement test, "It is a focus, not the focus." Echoing some of the parents, the principal and staff seek to have students "feel good about doing math." And, with this balanced approach, Bellcroft does better than most schools on the achievement exams.

specialist teachers

Mr. Woodman is careful as he explains his school's success. He cautions that what works for Bellcroft wouldn't necessarily work for a school where the students' home needs are not so well met. Having said that, he explains that departmentalization has contributed to the effectiveness of math education at his school. The size of the school means that there can be several math teachers who are subject specialists with full time math assignments. He tells us,

> The teachers who teach math in this school are experienced in math teaching and they have been trained in math. It is either their major or their minor.... We feel this is important because of the nature of the students we serve. A good number of them are sharp enough to be asking the tough questions. The questions that might go beyond the curriculum as stated. And as far as our students who are having difficulty are concerned, they need people with experience who can dig into a bag and pull out three or four or five different ways to present the same material. We have just found that that is more... probable... from teachers who have a specialty in math rather than those who are teaching it along with a number of other subjects.

team planning and decision-making

As a department, teachers enjoy teacher-directed decision-making and team planning. We learn this as Mr. Woodman modestly explains how the school "isn't perfect":

> Now, are we perfect? Or do we have all the answers? No. We constantly have some concerns. Right now, one of the biggest things that we have to address, is the impact of the way the new math program has been implemented. Because I personally have some questions and concerns with the implementation process in terms of the way it has hit our grade nine students two years in a row.... Our math department sat down and looked. They said, 'We did this last year, what should we do differently? And as a department, they changed some things. They altered

> some units in terms of when they were addressed. For example, they didn't start this year, at "unit one," like they did last year. Because it's a more nebulous unit. It's hard for kids to get a handle on. So, this year, they went right into a meat and potatoes unit, data analysis, a unit where the kids could get their hands on the math.

As well, the math department has full control of the choice of text book, the distribution of budget funds, and their professional development decisions. Mr. Woodman says,

> It's my job to make sure I can wheedle around and get the resources to them. It's their job to determine how they are going to divide that up. And that's got to be done in a team concept. That's got to be done with a team approach. Maybe we just take it for granted. Doesn't everyone do that?

trust

From this discussion of team decision-making, it is becoming clear to us that this principal has great trust in his teachers and in delegation. We ask him to explain the sense of teacher empowerment that we have observed. Mr. Woodman proceeds,

> When we as a staff, or we as a department in the school, make a decision, that's a decision.... It doesn't then come to me and I either veto it or say 'Well, rethink that' or 'Are you sure about that?' or 'We've had some parent comments....' No, that's the decision. And then if there are issues with the decision, the matter goes back to the teachers.... We're talking about professional people. People who have four... five... six years of training... and years and years of experience. How can anyone not capitalize on that? That's where the expertise is.

"they need to know we care"

Continuing his explanation of school policies that support success in mathematics, Mr. Woodman talks about the Class Deportment Sheets, which track students period by period. These "CD sheets" are "a lot of work," says the principal, "but at this age, it's pay me now or pay me later.... The kids need to know they are accountable. They need to know we care." The CD sheets follow a class of students as they move from teacher to teacher through the day. By each student's name, there are opportunities for the teacher to note attendance, tardiness, disruptive behavior, etc. If there are problems throughout the day, the student serves a detention.

> Students need to know that our job is to get them prepared for high school. The sheets are intended to flag all of the things that they need to get in place to be successful in high school and in the world of work.

This is a system that connects the students' interactions throughout the day. The principal warns, "In a departmentalized system, the potential is there for dividing the child up into little pieces, instead of someone taking a look at the whole person." The CD sheets help insure that Bellcroft School sees the "whole person."

46 extra hours

Explaining the school's success, the principal also notes that instructional time in math at Bellcroft exceeds the provincial minimum by 46 hours. (The provincial requirement is 100 hours.) He says that although the timetable exceeds the minimum instructional time in all core areas, the amount of extra time offered is greater in math and language arts than in social studies and science. The school board priorities have guided this choice by putting a special focus on achievement in math and language arts.

help for students who struggle

Mr. Woodman also describes a learning resource room with a teacher who gives assistance to students who are struggling. This teacher also has a strong background in math. Students can request help from the resource room themselves or can be referred by their math teacher. The resource room offers students one-on-one tutorials on their course work, but as well, students can use this opportunity to engage in a program that is tailored to their needs. This is particularly good for students who transfer from outside the province. Mr. Woodman also knows that the resource room helps students with a history of trouble in math. He says,

> Interestingly enough, we have identified that the problem is not so much in the area of ability, as it is in attitude. They have a feeling that they are poor in math and they make it a self-fulfilling prophecy. One of the jobs we have is to develop positive attitudes towards math in the students and to bolster them in their self confidence.

Bellcroft works toward this attitudinal change knowing that success is the best teacher. The principal explains,

> Success usually comes in small steps. It comes better in an environment where teachers are dealing with a smaller group of students, rather than trying to accommodate for the at-risk students in the regular class structure. There is too much pressure to cover the curriculum. The curriculum is heavy. There is lots to get through. The opportunities for success for at-risk kids are limited in that situation. But in a resource room situation, where the teacher can actually show them, they say, 'Hey, I got this right. I know how to do this.' And from there, the students' desire to try in math, instead of give up, is bolstered.

Additionally, the school has a "senior adaptation" program that gives students who are identified as having learning problems the extra attention they need. The principal explains that there is an automatic assumption that these students are weak across the board, which, he says, is not the case. The adaptation program at Bellcroft School tries to tailor a program to each individual student's needs. For example some students are able to cope in a regular math environment but need the special attention in language arts. He emphasizes,

> We are very careful not to take a blanket approach to students having difficulties.... We do have some of these students integrated into a regular class. Some are in the regular class on a regular program. Some are in a regular class with modifications to the program which are arrived at between the regular math teacher and the adaptation teacher. And then there are some that work with the

> adaptation teacher for their whole program. Those are the students who are still trying to make sense of basic skills development—adding, subtracting, multiplying, and dividing. And trying to make sense of that.... All you have to do is think of those students being in a regular class environment, with 28 to 30 students in the class, and how much time the teacher would have to meet their needs.

Mr. Woodman specifies that the extra time for math in the school timetable and the specialist teachers who teach it are factors which help the stronger students at the school continue to succeed. And there are many. "But we also have a number of things in place that help the at-risk kids continue to grow."

math contests

For the students exceeding the standard of excellence, the school offers involvement in math contests. "The tests," according to Mr. Woodman, "have a tremendous amount to do with our school achievement for many reasons." The school has a great number of students in all grades who write the tests. He beams as he tells us,

> All the students take an immense amount of pride in the math contest achievement, as they do in our sports teams and our debate club and our school band. When Jack Flynn, at our school assemblies, recognizes the achievement of our students in the math contests, locally, provincially, nationally, and internationally, everyone stands up and takes note of it... All of that helps build positive attitudes toward mathematics.

trying out computer-assisted instruction

At the district level, Mr. Woodman credits the emphasis that the jurisdiction places on math achievement. As we have said, it is a board priority. Also, the principal sees the district partnership with a major publishing company as important. At Bellcroft School, Mr. Flynn and Mr. Chieng are writing and developing computer-assisted instructional programs at the grade seven and eight levels. He says cautiously,

> We're 'trying them out' this year. Each teacher is trying different sections to see how it actually fits with our programming. I know there are other schools who are on a pilot basis. They have put a classroom, for example, on the computer-assisted program. There, the computer assisted program is the math program. But we have not taken that approach.... We consider the computer-assisted program a resource, not the entire program.

empowerment: in the district, school, and classroom

Also contributing to the successful math achievement is the way the district empowers principals with site-based decision making, thus ensuring that schools can meet the needs of their specific learning communities.

> You alluded to teachers being empowered... our school district has really empowered principals. There are no levels in our district between the principal

> and the superintendent. We are as senior management as you get because there is no one in between.

He describes "principal groups" that meet to discuss issues like the implementation of the new math curriculum and the quandary of how to deal with the "bridging courses" that will be necessary in the high schools. Through the district communication structure, principals share ideas and stay abreast of issues that affect students as they move to and from other schools.

As Mr. Woodman points out, the district's respect for principals finds a parallel at the school level in the way that he himself delegates to his subject departments and in the way that teachers work together. They are trusted to make choices that serve the needs of their class, just as the principal is trusted to meet the needs of his community. And Mr. Flynn and Mr. Chieng similarly respect their students' ability to make decisions. For example, they expect students to decide whether to take notes in class. Students also choose whether or not to complete homework or seek extra help.

"the people!"

When asked about his school's greatest asset, Gerry Woodman says, "the people! There's no doubt about it. The physical building is not nice at all. It's a box. It's quite institutional in looks. Seven portables on site.... No, it's the people." And his office tells that story well. The room does not seem to have changed since the school was built in the late 60s. There is dark brown panel board on the walls. Behind Mr. Woodman's desk hangs a red wool macramé owl, likely a student's work. We conclude from these choices that, indeed, people are the focus of this school. The building serves the learning.

Mr. Woodman describes the Bellcroft "organization":

> Everyone feels they are a member of the organization, not just the teachers. It's a place for everyone to learn and grow. The students are not the only ones learning and growing in this school. The staff are as well. We are all in this together. The students aren't the clients or the customers. They are members of the organization just like everyone else.

Students and teachers work together to find ways to make the school an even better place. Students are often consulted on challenges that face the school. Groups such as "peer support" are vital to the way Bellcroft runs. "We try whenever we can to allow them a say in their own education."

matching the school to the community

Mr. Woodman thinks that his school can get away with allowing the students such a large role in decision-making because

> they come from homes that value education and they come through the door ready to take part.... I'm not saying that what we do would work in every school, I'm not saying it should.... I can give you another example, the worst thing that some of our schools could do is go to a departmentalized system like we have. We can do it because our children come to us well equipped to handle the day. If you are

> dealing with a school where the kids are coming through the door poorly clothed, poorly fed, from disadvantaged home environments, maybe you would want to have that school set up on a core basis, where the kids only see one teacher who would work with them the whole day on the myriad of problems that they have.

There is no "one way" for this principal. He says that the district gives him the "flexibility and the responsibility to develop a school community that really reflects the needs of the people that we are serving in that community."

advice to principals: "the teaching staff is the key"

Mr. Woodman is reluctant to offer advice to other principals. He knows that solutions do not necessarily transfer from school to school. But he does offer that, for him, his "teaching staff is the key. It will all start or end right there." And he repeats that he is a strong proponent of specialist teachers provided that the student's home needs are met. "The teacher is always the key.... The only people that can really chart the success of the math program in our school are the teachers." He acknowledges support from curriculum and consultants but maintains that, in the end, the teachers need to know the kids and the math well.

Even though Bellcroft attracts students from supportive homes, the principal can see how a teacher in a disadvantaged community is still making important decisions. "I would say, a smart math teacher, seeing a kid hungry, would feed the kid before trying to teach the math."

curriculum and student learning

Mr. Woodman is a principal who reflects on developmental psychology and the appropriateness of curriculum:

> I have observed that, of any subject in school, math seems to give the largest number of students the most difficulty.... And I really believe that in curriculum development and in curriculum work that there hasn't been a close enough tie between the psychological development of students at a given age and their ability to abstract or handle some of the math concepts that are thrown at them at that time. There isn't that mesh. At the elementary school, the kids are still operating at the level of concrete operations. By junior high, they have not matured that much. So, if you're going to start throwing abstract concepts at them, it's no wonder they have trouble.

We think his thoughtfulness and willingness to question are qualities that contribute to this school's success.

assessment and the achievement exam

With the same reluctance that he expresses when asked to advise other principals, Mr. Woodman avoids naming the teaching strategies that work in the math classrooms at Bellcroft School. He does, however, say that the majority of the students' marks for mathematics come from tests. He credits the math teachers for recently incorporating journals into their math program. And he mentions that a practice of getting parent signatures on test works well in this

community where the parents are supportive of education. The school has four formal report cards and many teachers use interim report cards as well.

The provincial exam counts for 10% of the students' mark in mathematics. On the low percentage, Mr. Woodman says, "In the main, we find--" Then he hesitates,

> How can I say this because this will sound snobbish?... We just find, relative to our own exam and the kinds of things we test the kids on, it's not quite as rigorous. So we don't count it as heavily.... We do not feel that, in an hour, any exam, no matter how well it's comprised, would be able to give a valid indicator, on its own, of student achievement.

balance teaching

As for classroom teaching, he advocates "balance" and believes that his teachers are able to deliver it. He can see that there needs to be a balance between "telling students in rote and student inquiry." He think that some concepts need to be taught by telling, in order to keep the curriculum moving quickly, while others can be learned more slowly through inquiry and discovery. "I think we can go too far one way or the other." He illustrates his point by going into role as a teacher talking about the circumference of a circle:

> $C = \pi d$. Memorize it. Learn it. Don't try and figure out what it means. When you are trying to figure out the circumference of a circle, just multiply the diameter by π.

He explains that given how hectic the math program is, the teacher might choose to teach by telling so that more time can be spend on something else. On the other hand, the principal offers that a different approach might look like this:

> Why is the value of π 3.14...etc. Did somebody pull it out of a hat? Did somebody say, 'Let's make π equal to this because it sounds good?' No, it's the relationship of the diameter to the circumference and it doesn't matter what circle you're dealing with, it always comes out that the circumference is just a little better than three times the diameter.

Woodman underscores that there is no right or wrong way to teach. He does caution that a teacher who tries to teach for understanding all the time, so "the kids have to know the meaning behind <u>everything</u> and understand it, will never get through the math program.... On the other hand, those that don't promote understanding at all, in math, and who rely on rote completely, don't have the answer either." In order to reach the diverse students in the classroom and meet the curriculum, both approaches are necessary.

the multiverse

> If the golden solution was there, if someone came up with the one way that works for everyone, hey, we would jump on it. But so far we have not seen one come along. So, if you find it please let us know. (He laughs, then becomes earnest again.) But I don't think it's there. Think of the human being, think of how diverse, how unique everyone is and how everyone brings a different set of values

and experiences and preferences to the situation.... It's great stuff. I would think it's better that way than if it was all one.

Mr. Gerry Woodman appreciates difference and in this spirit pulls together the actions and preferences of his staff, students, and community, without prescribing any particular "right way." We think that Jack Flynn, John Chieng, and their students thrive under the leadership of this principal. The following are accounts of these teachers' interaction with students.

Shannon Sookochoff

Mr. Flynn

A pillar of the mathematics community

Mr. Jack Flynn has taught math at Bellcroft School for 28 years. He is a tradition in his own right. He is well prepared. His course overview reads like a text book page, and his lessons unfold with the same finesse. His students and their parents talk about the way Mr. Flynn is available for extra help out of class, the way he gives clear explanations with practical and relevant examples, and the way he uses manipulatives to help students understand. Additionally, Jack Flynn has been and continues to be active in developing curriculum resources for math teachers. He has a strong background in mathematics and mathematics education. And he knows kids.

Part 1: Parents who believe in the teacher and model a high regard for education

It is clear from the principal, teacher, and parents themselves that the parents of Mr. Flynn's students are interested in their children's education. From the class grouping that I observed, parents of nine children responded to our questionnaire. And when asked what makes the difference as to how well their child does in mathematics, they overwhelmingly said, "The teacher!" Some credit his practice time and his "hands-on" activities. Another specifies that it is Mr. Flynn's encouragement that makes the difference. (One parent reports, "At midterm, we switched math teachers—now he is doing much better in math!") These are parents who understand, however, that it is not simply the teacher who makes success in the classroom. One parent mentions the ability of the child and her willingness to listen. Another mentions the relationship between the child and the teacher. Another credits an inherited family knack for mathematics. Parents also acknowledge the tools and resources available to the teacher, a supportive home environment, and a good school environment.

These are parents who stay abreast of the activities in Mr. Flynn's class. Above all else, they recognize the importance of Mr. Flynn's availability for lunch hour and after school help. As well, they know that he gives clear explanations and reviews in class. One parent writes that "feedback on quizzes" was a very important contribution to the child's success. And another very pleased parent says that Mr. Flynn's "strategies are too varied to list—see a curriculum document." I would agree. Mr. Flynn draws from a long and full career of experiences with teaching children mathematics. His teaching is a potpourri of practical examples, games, worksheets (from a variety of sources), reviews, previews, textbook assignments, math warm-ups, overhead transparencies, demonstrations, diagrams, hands-on experiments, and journals. One might say that he employs everything but the kitchen sink. (But, then, one would have to think twice, because, in fact, Mr. Flynn does use his kitchen sink, as you will see.)

Part 2: Students who value their teacher

Extra help

When asked what their teacher does to help them learn mathematics, Mr. Flynn's students have a lot to say. But, more than any other teacher initiative, students cite Mr. Flynn's willingness to stay at lunch time and after school to give them individual help. And I can attest to his commitment in this regard. Students do indeed come to Mr. Flynn's room after school with questions for him. They know he will be there, because he makes a point of it. There is pedagogic reliability in this practice. In being available to his students during his "off duty" time, Mr. Flynn builds a strong relationship between them and himself. During my visit to Bellcroft School, I witnessed the following interaction.

Hallway Tutorial

I imagine that to a student such a gesture is rich with meaning. From this incident, Adam must know, on some level, that his learning is important to Mr. Flynn, that adult conversations do not come first. Perhaps Adam senses, as I do, from the tone of Mr. Flynn's voice, that mathematics will most surely reveal itself, that Mr. Flynn will help Adam understand. And, certainly, Adam knows that he is welcome to ask other questions in the future.

As Mr. Flynn and I are talking on our way down the hall toward the office, he senses that one of this students, Adam, is following us closely. He politely stops our conversation and invites a question from the boy.

"Yes, Adam."

"I'm not sure how to do number five," Adam says with his binder open revealing a worksheet.

With a voice that suggests "everything is under control," Mr. Flynn calmly points out a small detail that the student has overlooked. "The area of the base is given in the question, so you would use the general formula, $V = Bh$."

Adam nods and indicates that he understands.

Mr. Flynn and I continue our conversation.

Clear explanations

In addition to the extra help, students are grateful for Mr. Flynn's explanations. They notice the way he clarifies issues for them in class, goes over tests, uses diagrams, and answers their questions. They also value his patience. Here is a glimpse of Jack Flynn in class.

Review of Area

Mr. Flynn creates a handout himself that will guide students to review past knowledge and prompt them to develop curiosity about the areas and volumes with which they have trouble.

This is the first day of the students' in-class work on area and volume. Mr. Flynn asks the class to turn to the three-page handout that he gave them last period (see Figure 1). He tells them that these sheets will become their notes and that they should fill in whatever they did not understand last night.

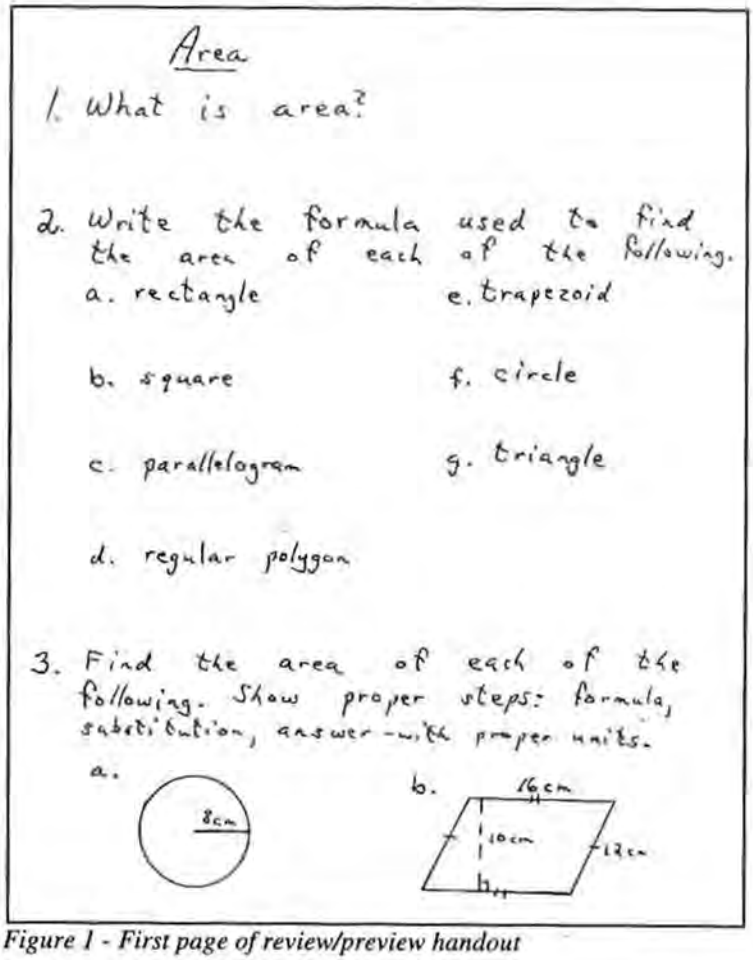


Figure 1 - First page of review/preview handout

When asked Warren reads his definition of area, which seems to have come from the glossary.

Mr. Flynn knows the importance of student explanations.

Noting this with a smile, Mr. Flynn cautions, "Just so long as we understand. Sometimes it's better to put it into your own words rather than just copying it out of the dictionary or glossary. But yes, area is the measure of the surface that a two dimensional shape covers. It is measured in square units."

Mr. Flynn does in fact "take time." Here, he reminds students of the common sense of what they are doing. He makes connections for them between the exponent and the number of dimensions.

Then Mr. Flynn goes to the board. "Some of us forget. And we mix up linear measure, area measure, and volume measure." He begins to write $cm \times cm = cm^2$.

"If you are measuring area, you have one dimension by another dimension. So you say centimeters by centimeters which is always going to give you... square centimeters."

The teacher repeatedly offers tips such as this one.

Then he explains linear measure and volume in a similar fashion, concluding, "When we have area, we are multiplying two dimensions. That's why we have centimeters squared. When we have volume, we have centimeters times centimeters times centimeters which will give us cubic units."

Mr. Flynn relies on his students having a strong background to draw from.

Then he adds calmly, "Don't forget that."

Mr. Flynn encourages students to have different approaches.

Then Mr. Flynn returns to the handout. "These are all formulas which you have all taken before, some of you as early as grade 6. This is just a quick review because we'll use these formulas as we go forward to some of the other questions." Then he asks, "The area of a rectangle, Susan?"

He assures them. He gives them another tip to prevent confusion. Mr. Flynn is like a tour guide: "I've been here before, this is nothing to worry about."

Susan says, "Area equals base times height."

And Mr. Flynn begins a list on the board. "There are a variety that we might have here." He writes $A = bh$. And with student input he adds $A = lw$ ("length times width") and $A = ab$ ("altitude times base").

"Please remember that these are just letters that represent different dimensions of a rectangle. So don't get confused. That's all it is.... They all mean the same thing."

Even though he suspects that his students will not know, Mr. Flynn asks them to think about it.

Very quickly, the class reviews the square and the parallelogram, then goes on to the regular polygon.

"Does anybody know what the formula is for the area of a regular polygon?" asks Mr. Flynn. "Susan?"

"No," she shakes her head.

His prompt helps push Susan toward a strategy. She has divided shapes up before.

"Okay, this is probably one that you haven't seen before. So let's just take a moment to look at that."

Mr. Flynn makes connections to other learning.

Mr. Flynn draws a hexagon on the board. "If we take our regular hexagon and divide it up. What do we have to divide it into?"

Now Susan answers, "Six triangles."

"Six congruent triangles. That's right. This distance here..." he points to the apothem, "is the altitude of the triangle. And a side of the hexagon would be the base of each triangle. How do we find the area of triangle?" (See Figure 2.)

Kevin offers, "*Base times height divided by two.*"

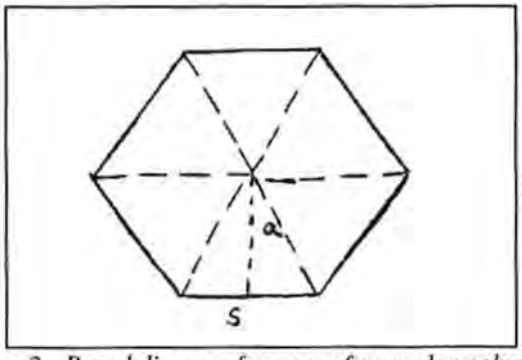


Figure 2 - Board diagram for area of a regular polygon

He withholds the new vocabulary.

He's asking them to think about a general rule.

"Right." Mr. Flynn gestures to the parts of the diagram that would be the base and height of the triangle. "*This* times *that*, divided by two. I'm just going to call this '*a*' for 'altitude' right now. There is another word that I'll tell you in a minute.... So we would have '*a times s divided by* 2.' And how many of those triangles would we have?"

He takes their thinking and forms it into a general formula.

Again, he asks them to remember something. "This is important," he implies. "Take note."

Many students call out, "Six."

"How many would we have if we had a regular pentagon?"

"Five."

"An octagon?"

"Eight."

"Right, so it's the number of sides." Mr. Flynn concludes.

He returns to his board formula *as/2* and adds, "So, I'm just going to multiply that by *n*, standing for the number of sides that we have. Now, I'll write it in this form: *1/2 ans...* or... *ans over 2*."

He continues, "*a* is the altitude of the triangle, but when you get a question like this, you're not going to have it divided up for you." He draws a diagram of the way a question might appear and puts a dotted line for the height of the apothem. "And the *a* will stand for, and write this word down so that you remember it. 'Apothem.'" Then he prints the word on the board.

"So for any regular polygon, that's how we find the area. The apothem times the number of sides times the length of each side divided by two."

Kevin asks, "Is that the same for a circle? Is that thing in a circle, the radius, called an apothem, too?"

"No. This only works for regular polygons. The distance from the center of the polygon to the midpoint of the side.... That's called the apothem."

Kevin asks a question at the end of that passage that causes me to think carefully about Mr. Flynn's practice. From my perspective, the relationship between the apothem and the radius is an interesting one to explore. Yet, Mr. Flynn chooses to stress the distinction here rather than the relationship. Knowing that it is still early in the class's learning about the area of a regular polygon, Mr. Flynn likely judges that their understanding is still fragile. Thus, the similarity between the apothem and the radius is possibly too subtle a point. While the discussion might be very good for Kevin at this moment, Mr. Flynn must consider the engagement of the entire class. Other students might not be so interested in the apothem-radius issue. It may well be that Mr. Flynn and Kevin find time to talk about relationship between the circle and the regular polygon in a one-on-one session. Also, I have noticed that the moments at which Mr. Flynn does choose to pause and elaborate, like when he made connections between exponents and dimensions, are ones that connect the students and the math to the concrete world. The radius-apothem relationship, on the other hand, is an abstract notion. This seems to fit with something the principal said about the junior high student being more concrete operational than the mathematics curriculum acknowledges (see page 126–127). Additionally, perhaps Mr. Flynn sees the need for balance the way Mr. Woodman does (see page 127–128): that the teacher who tries to teach for understanding all the time, so "the kids have to know the meaning behind everything and understand it, will never get through the math program."

In any case, the students appreciate the clarity of Mr. Flynn's explanations. I can see that he incorporates student thinking into the explanations and uses his own experience with student knowing and teaching to provide a framework that pushes them ahead. For example, when a student demonstrates that she is able to predict the number of triangles that will be made from each regular polygon, Mr. Flynn expresses her understanding as if it were a general rule in her mind: the number of triangles is the same as the number of sides. It may have been. But if not, his nudge may help her to see the general pattern.

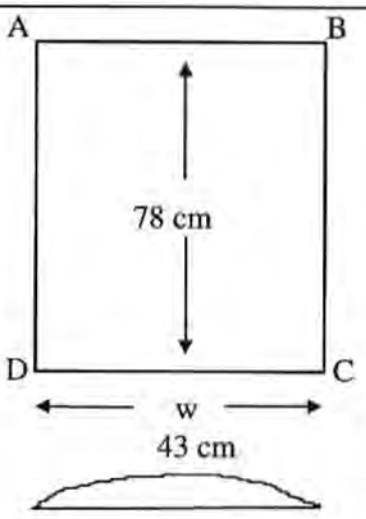
Student involvement

Another of the themes that I see, from looking at the students surveys, is in the area of student involvement. Mr. Flynn's students say that he makes math "fun." They appreciate his examples, especially the ones that make sense to the students' lives. They say he "takes time." And I, too, see that this is so. Mr. Flynn is not in a hurry to get through the curriculum when it comes to making math apply to his students lives. He is not pressing through a text book. His lessons look more like this--

Mr. Flynn draws from a variety of resources and appeals to the seasonal interests of his students.

The Strike Zone

"Let's have a look at a couple of questions and see how you make out." Mr. Flynn puts a problem on the overhead projector. The problem is taken from the *Journeys in Math* text book (see Figure 3). It asks students to calculate the area of the strike zone of a particular baseball player. Baseball season is about three weeks away.



Problem 1
In baseball, the pitcher must throw the ball over home plate and between the batter's mid-torso and knees. This is called the strike zone, and is shown here as the area ABCD. Calculate the strike zone for the player.

He encourages the students to make meaning out of a word problem themselves as they would need to in an exam situation.

Figure 3 - An area problem taken from ***Journeys in Math***

Unveiling a part of a problem at the left side of the board is a daily practice for Mr. Flynn. His preparation affirms the confidence his students have in him.

With no other direction, Mr. Flynn says, "Do that one for me, please, everybody."

Students stare at the overhead screen and gradually begin to solve the problem. There is silence in the room, broken only when Mr. Flynn focuses attention to the left side of the blackboard.

"The diagram is reproduced for you over there on the board in actual size, if you can't read what it says on the screen."

Mr. Flynn supports Jordon by modeling, so that he might eventually be able to read a problem himself.
The teacher shows that this problem exists in the real world.

Jordon puts up his hand.

"Yes, sir," Mr. Flynn acknowledges him.

Jordon doesn't understand what to do.

"What does it say..." he directs Jordon's attention to the words and reads, "'calculate the strike zone' for 'the area ABCD.' That's this shape there." He points to the rectangle on the screen.

He involves the students in his analysis.

Mr. Flynn allows a little more work time before he interrupts, "This is a typical major league player strike zone." He puts his hand under the base of the rectangle he has drawn on the board. "This dimension is, of course, the width of the plate." He gestures to the height of the rectangle, "This dimension would vary with the height of the--" He waits.

He asks the students to think critically about the problem.

"Batter."

"Batter."

"Batter." Several students respond.

Smiling, "--the batter. That's right.... The diagram may be a little bit misleading. Why is that? Are any of you baseball players?"

The life size drawing helps students see the difficulty of hitting the target from 27 meters away and understand that measurement has meaning.

Brad answers, "He's not standing up."

"Ya, and the strike zone doesn't really go up to the shoulders. It only goes up to the top of the letters on the uniform. But the distance is fairly typical." Then he asks the class, "So what's the area?"

Wayne responds, "3354 square centimeters."

Again, Mr. Flynn's preparedness is evident. He "reveals" the mathematics.

"Yes, 3354 square centimeters, 43 times 78. That's the target that the pitcher is looking at when he is standing out there, 27 meters away form the plate. He's trying to hit this particular zone. For those of you who haven't done it, it is not that easy to do." Mr. Flynn notes that the pitcher is not just trying to hit the middle of the target either. He explains that the pitcher aims for the corners of the strike zone in order to make it more difficult for the batter to hit.

The Kitchen Sink

These students can work independently.

"Okay, let's have a look at another question that has to do with volume." Mr. Flynn moves the paper on the transparency to reveal the second problem (see Figure 4).

The problem he chooses asks students to think, not

just solve. They must estimate or measure the dimensions of a sink, thus reviewing previous skills.

Problem 2
Daniel starts to fill the sink to do the dishes. just as he turns on the water, the phone rings. If the water comes out of the faucet at a rate of 100 cm^3 per minute, how long can he talk on the phone before the sink overflows?

Figure 4 - A volume problem

Students are involved.

Again, the class goes silent as they begin to work on the problem, this time, without being asked.

After about 30 seconds, Helen asks, "How big is the sink?"

Mr. Flynn is pleased, "Oh, I was wondering if someone would ask me that question. Yes." He begins to sketch a sink on the board. "What would be a size for a typical kitchen sink? Remembering of course that we have round corners, we'll pretend that we've got a rectangular prism."

Mr. Flynn is prepared for instruction.

I wonder if they will look at their own sinks differently tonight.

Amanda says that she thinks the width of the sink is 45 centimeters.

Chris says that it's 50 centimeters long.

Mr. Flynn labels their ideas on the board diagram. "About how deep do you think it is?"

"20."

"25."

Many students offer possible depths for the sink and begin to discuss their estimations. Mr. Flynn chooses one depth for the diagram.

Leaving the students estimates, Mr. Flynn reveals, "I measured my kitchen sink this morning, so we'll use those dimensions. But you're not too far off...."

He goes on to share the measurements of his sink and guide the students in solving the problem.

These examples ask students to think about their experience of the world in a mathematical way. They begin to ponder about the amazingness of a good pitch or about the size of their own kitchen sink. And through this example, they see that Mr. Flynn lives in the world in this way, the mathematical way. The students also see his care for them. They experience the way he makes reference to their lives. He lets them know that he was thinking about math, and them, this morning as he measured his sink. Math is part of his life. Teaching is part of his life.

Demonstrations

Also important to both students and Mr. Flynn, are his hands-on examples. He is known by his colleagues for using manipulatives. The following passage describes a demonstration using concrete objects.

A Cube, a Square Pyramid, and Some Water

Mr. Flynn makes the math real by using objects.

Mr. Flynn holds up a clear plastic cube and asks, "What is this shape?"

He does not demand attention. He uses questions and depends on students' curiosity to focus them.

He invites students to participate in his thinking by using incomplete sentences.

Mr. Flynn does not correct Wayne. He models the appropriate name. But since Wayne seems to be stuck using an incorrect term, Mr. Flynn is explicit.

All students are watching now. The questions and props have gathered student attention.

Students are encouraged to make private predictions.

The word "relationship" challenges the students to think differently about the word. Mr. Flynn helps them make the connection by rewording the task.

Mr. Flynn takes this opportunity to give the class more information. The wait time has given them a "need to know."

Cindy and Brent answer casually, "A cube." The students are working on some questions that ask about the volume of prisms and most of them do not bother to take notice of Mr. Flynn at the front.

He continues, without demanding their focus. Laura has turned her back to Mr. Flynn in order to work on one of the problems with a colleague. "What is unique or characteristic about it?" he asks.

Although three or four students contribute, Wayne answers loudly, "All sides are equal."

"All sides are equal," Mr. Flynn confirms. "So, each of the faces is a--?

"Square" fills in Wayne.

"A square." Mr. Flynn, then holds up a pyramid and asks, "This is--?

"A pyramid," someone responds.

And Wayne clarifies, "A square based pyramid."

There are lots of students calling out answers. Mr. Flynn asks Laura to turn around now.

"It's a square pyramid because the shape of the base is a--" He pauses to give students an opportunity to engage. "--square."
Mr. Flynn takes out another pyramid and asks the students what it is called.

Wayne says, "A pentagon based pyramid."

"A pentagonal pyramid," Mr. Flynn affirms. "You don't need to say 'based' Wayne. You can just call it a pentagonal pyramid. That tells you that the base is a pentagon."

Mr. Flynn shows the class a few more three dimensional forms and asks for their names. For the last example, I hear the entire class answer, "Triangular pyramid."

Moving back to the cube and the square pyramid, Mr. Flynn asks, "I want you to speculate: what might be the relationship between the volume of the square based pyramid and the volume of the cube? They have exactly the same size base.... So on your paper, write what you think the relationship is between the volume of these two shapes. They have the same base and the same height."

Students begin to mutter to each other. David asks, "What do you mean by 'the relationship'?"

"How do you think the volumes would compare?" Mr. Flynn clarifies.

Students continue to puzzle over the question.

"Everybody needs to have something written down before we proceed. I'm not going to ask you what you have, just write down what you think the relationship would be."

After about one minute of think time, Chris asks about the heights, so Mr. Flynn repeats, "They have the same height, Chris.... Now you need to write down the relationship between the volumes.

The water seems to add suspense to the demonstration, as if the students are watching a magic trick.

Do you think this is twice the pyramid? Three times? Four? A quarter as big? 50%? What's the relationship between the volumes of the two shapes?"

He waits a little longer before asking, "Have we all got something written down now?"

"I do."

Again, students are mesmerized by what they see... and hope to see.

"Uh huh."

"Yes" several students answer.

"Some of you noticed that these shapes had holes in them. That's so that we can do something like this." He begins to fill the square pyramid with water from the plant watering can which he finds behind his desk. Students quietly watch.

They are surprised and impressed with the result.

"What I'm going to do now is pour the water from the square pyramid into the cube. And we'll see how far the water comes on the cube so that we can see how close our guesses were. Some of you have been guessing one thing. Some of you have been guessing something else. We'll see whether you are right."

Mr. Flynn begins to pour and the class falls silent.

Many of them have guessed 'one half' so are anxious to see the level of the water rise to the half way mark. However, when they see that the water only reaches to the one third mark, they are impressed and look at each other with wide eyes, nodding.

Mr. Flynn uses the demonstration to explain the general formula for volume of a pyramid.

Mr. Flynn uses concrete objects to make the math real for his students. His efforts are evidence of the trouble he takes in the name of student learning. Students seem to appreciate the time and energy he spends to make this impact on them and I think that the student–teacher relationship is stronger for it. As well, Mr. Flynn allows the math to attract the kids. He does not call them to attention with promises of an "amazing" demonstration. Instead, he begins modestly, using simple questions that ask students to listen, remember past knowledge, and fill in the blanks. He asks each student to make a guess, thus investing a piece of themselves in activity. And he pours water... which the students find captivating.

Hands-on and fun

Mr. Flynn used other manipulatives during my visits, too. To prepare for a test the following day, students reviewed their probability unit by working in pairs to play a game with dice: "Person A" would get a point if the difference between the values on the dice were 0, 1, or 2 and "Person B" would get a point if the difference were 3, 4, or 5. The students played intently. Eventually, they found that Person A usually won the game, then, using a chart, they verified that the game was not fair by calculating probability. At that point, Mr. Flynn asked, "How can we make the game fair?" The class came up with several ways to do so. Then, Mr. Flynn announced that for the remainder of the class they could play Crypto, a mathematical card game. It was obvious that students knew the game by the way they cheered, "YES!" The rest of the period was spent playing with numbers, thinking hard, and socializing.

I am struck by Mr. Flynn's choice to offer relaxed class activities such as this in the period before a unit test. This tells me that Mr. Flynn is confident in his students' ability. The activities he provides seem to help kids feel good about math, a theme that appears in both the parent questionnaires and the principal interview. Yet, the dice game was much more than skill-affirming recreation. It was mathematical knowing in action. From it, students would have this concrete experience to draw on when they write the test.

Part 3: Looking back, forward, and at the students:
A teacher who embodies tradition

As I said earlier, Jack Flynn has been at Bellcroft School for 28 of his 32 years of teaching. He left for a few months in the middle of his career to work as a math consultant in the board office, but discovered that he missed the classroom and the kids. He lives five minutes away from the school. He runs the annual Bellcroft Briar, a curling bonspiel, and has done so for 22 years. Behind his desk, I see a laminated poster of the bonspiel's structure with blanks so that each year, to organize the event, he just needs to write in the names of the new teams. He is also his school's representative for their local of the Alberta Teachers' Association. This he has done for 32 years. From his calm disposition, I can see that he is accustomed to being a teacher. He has routines. He can be counted on.

He is established and committed.

Jack Flynn has also been part of the Mathematics Council of the Alberta Teachers' Association (MCATA) for 25 years. He has presented at MCATA conferences and teacher's conventions in and out of his jurisdiction. His insights into mathematics education have prompted his involvement in the writing of educational resources. During the development of the Western Canadian Protocol for mathematics, Jack contributed to writing a textbook that would help teachers with the new curriculum. And his work in this area continues now with his efforts to develop computer assisted mathematics instruction for grades 7 and 8. His name is known in the district.

He has expertise and a history of professional involvement.

Knowing all of this, I have begun to think of Jack Flynn as embodying tradition. Let me be clear. This is not to say he is "traditional." Instead, I am referring to his "reliability," his "constancy." Considering his years of service to the same school, his dedication to annual school events, his commitment to his professional association, and involvement at the ground level of mathematics curriculum resources, I see Jack Flynn as a pillar of the mathematics and education communities. And as our surveys confirm, he is trusted.

"tradition"
"reliability"
"constancy"
"trust"

Even Mr. Flynn's course outline reveals a sense of history (and a sense of humor). In the outline, he has borrowed two humorous passages (see Figures 5 and 6). One, entitled "Ten Commandments of Mathematics," frames some practical advice to math students in biblical language, changing the popular teacher suggestion, "Read the

Mr. Flynn uses humor to invite students into the traditions of mathematics and the classroom.

problem," for example, into "Thou shalt read thy problem." The language connotes a sense of ancient and divine mathematical wisdom being passed through time. And, below the commandments, is a Family Circus cartoon. It animates an ordinary classroom desk, using speech bubbles, so that the desk may tell about its experience with a long history of students, while at the same time advising current young people on appropriate behavior. Both passages remind students of the established history of mathematics and school. Yet both also look forward to the year of mathematics ahead.

Ten Commandments of Mathematics

1. Thou shalt read thy problem.
2. Whatsoever thou doest to one side of the equation, do you also to the other.
3. Thou must use thy "common sense" else thou wilt have flagpoles 9000 feet in height. YEA...even fathers younger than sons.
4. When thou knowest not thou shalt look it up; and if thy search still elude thee, than thou shalt ask the all-knowing teacher.
5. Thou shalt master each step before putting thy heavy foot down on the next.
6. Thy correct answer does not prove that thou hast worked thy problem correctly. This argument convincest none, least of all thy teacher
7. Thou shalt first see that thou hast copied thy problem correctly before bearing false witness that the answer book lieth.
8. Thou shalst look back even unto thy youth and remember thy arithmetic.
9. Thou shalt never divide by zero.
10. Thou shalt learn, speak, write and listen correctly in the language of mathematics and verily A's and B's shall follow thee even unto graduation

Father Stanley Bezuka
Boston College

Number 4 jokes about the all-knowing teacher. Yet, joke aside, in this classroom, there is some truth to that--Mr. Flynn is trusted to know the mathematics and the way to student understanding.

***Figure 5** - Father Stanley Bezuska's "Ten Commandments of Mathematics"*

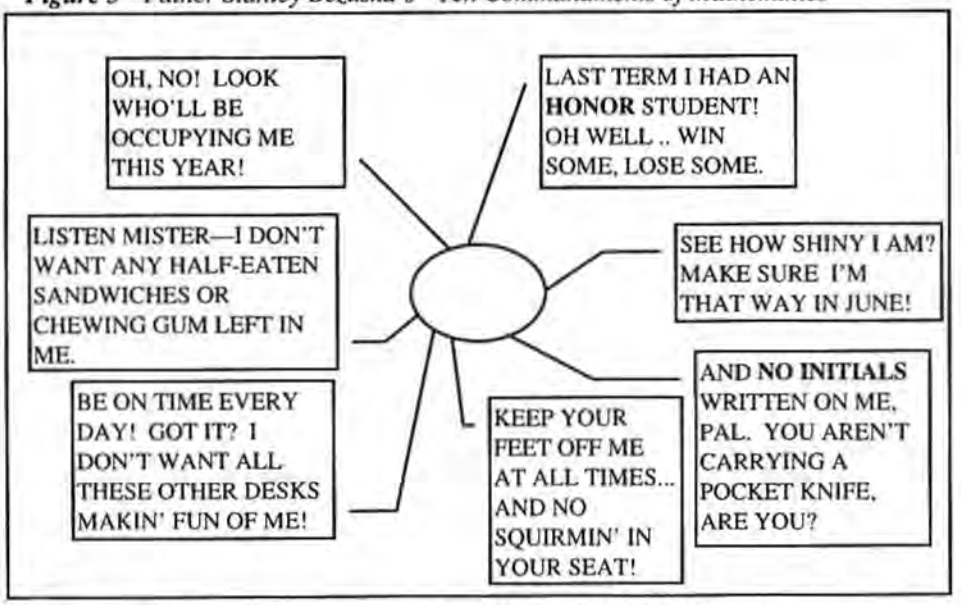

OH, NO! LOOK WHO'LL BE OCCUPYING ME THIS YEAR!
LAST TERM I HAD AN **HONOR** STUDENT! OH WELL .. WIN SOME, LOSE SOME.
LISTEN MISTER—I DON'T WANT ANY HALF-EATEN SANDWICHES OR CHEWING GUM LEFT IN ME.
SEE HOW SHINY I AM? MAKE SURE I'M THAT WAY IN JUNE!
BE ON TIME EVERY DAY! GOT IT? I DON'T WANT ALL THESE OTHER DESKS MAKIN' FUN OF ME!
AND **NO INITIALS** WRITTEN ON ME, PAL. YOU AREN'T CARRYING A POCKET KNIFE, ARE YOU?
KEEP YOUR FEET OFF ME AT ALL TIMES... AND NO SQUIRMIN' IN YOUR SEAT!

***Figure 6** - The words of an experienced desk from A Family Circus cartoon reminding students of the past and future of which they are part*

A teacher who looks forward

Jack Flynn gives his students a clear picture of what the future in his class will look like. His course outline looks like a page from a published text book (see Figure 7) and reads like a succinct version of the curriculum.

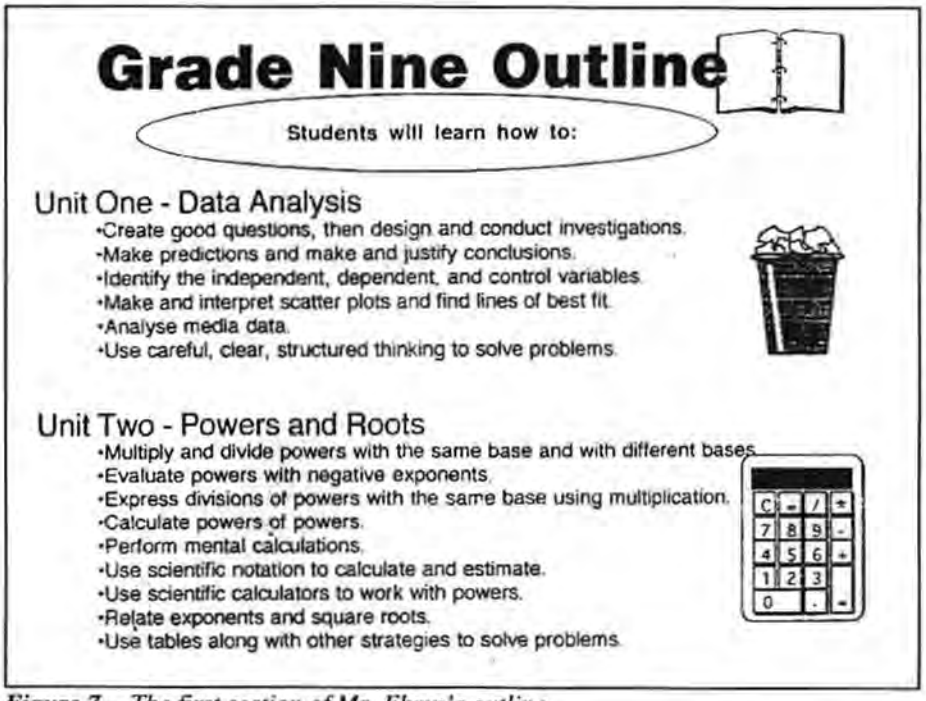

Grade Nine Outline
Students will learn how to:
Unit One - Data Analysis
•Create good questions, then design and conduct investigations.
•Make predictions and make and justify conclusions.
•Identify the independent, dependent, and control variables.
•Make and interpret scatter plots and find lines of best fit.
•Analyse media data.
•Use careful, clear, structured thinking to solve problems.
Unit Two - Powers and Roots
•Multiply and divide powers with the same base and with different bases.
•Evaluate powers with negative exponents.
•Express divisions of powers with the same base using multiplication.
•Calculate powers of powers.
•Perform mental calculations.
•Use scientific notation to calculate and estimate.
•Use scientific calculators to work with powers.
•Relate exponents and square roots.
•Use tables along with other strategies to solve problems.

***Figure 7** - The first section of Mr. Flynn's outline*

The outline is clear and direct and such is the image of the future for Mr. Flynn's students.

His use of verbs (rather than a list of concepts) parallels the active nature of his classroom.

And, his graphics offer a peak into a teaching style that is reliant on the fun and learning of concrete manipulatives.

He has incorporated graphics throughout such a cartoon about math anxiety and preparedness. The picture shows two students, one who has studied for a math test and looks confident, and one who has not studied and looks panicked, sweat pouring from his nervous face. In addition to giving some amusement, the image is perhaps Mr. Flynn's offer to his students of what the future might look like.

The image suggests that students should take responsibility for success in mathematics. The student surveys are evidence that they hear this message. Their top three suggestions to other students are: ask questions, pay attention, and study

Mr. Flynn makes a practice of looking ahead. In addition to the detailed course outline in September, at the start of each unit students get a glimpse of what is in store and why they need to know it. For example, after some examples with area and volume, Mr. Flynn places an overhead on the screen entitled "Why do you need to learn this?" (See Figure 8.) And he elaborates by explaining that surface area and volume are considered when manufacturers decide on the way a product is packaged.

Looking forward here extends more than just to the end of grade 9. This vision is of the students as adults and decision-making members of an economy.

Why do you need to learn this?

Measurement is a part of everyday life — from wallpapering a room to baking a cake, and from planting a garden to tiling a floor.
Exploring two- and three-dimensional shapes can help you to solve problems in design, economics, and geometry.
The relationship between the surface area and volume show how to use dimensions in order to be **cost effective**. This chapter will help you develop formulas and methods to calculate the surface area and volume of three-dimensional shapes.
Note: Cost effective refers to achieving the greatest result from the least cost for any given operation.

***Figure 9** - A unit overview connecting math to the student's future*

A teacher who gives careful attention to the present

Jack Flynn is very attentive to the present. His students seem to enjoy the time they spend in his class. Their amazement at the volume demonstration, their commitment to the dice game, their mathematical conversations with each other as they sit in pairs, and their eagerness to visit and play Crypto are indications to me that this teacher is not just preparing students for their future or introducing them to established mathematics. He is, as well, addressing the present moment needs of the teenagers in his class.

He claims that compared to other teachers, he is not very close to the kids. Yet, I think that the relationships between students and the teacher here are strong. I think so because, in addition to making math fun and relevant, Mr. Flynn does not seem to "demand" anything from his students. He has expectations that they will do well in math, but he does not prescribe that they get extra help or that they take notes in class. "I'm not going to tell them how they should learn. By the time they are in grade 9, they know what works best for them." (He trusts them, as Mr. Woodman trusts his teachers.) And, in case they need him, he is always in his room well before the bell and long after school is dismissed. Jack Flynn "accepts" students for who they are. He tells me that, although other teachers use the Class Deportment sheets to assign detentions, he hardly ever makes a comment on them. He is able to deal with the few behavior problems he has himself; there is no sense getting the student in trouble with yet another teacher. Mr. Flynn cares about his students.

Conclusion: Bringing out the best in people

In the end, I am convinced that Mr. Jack Flynn's students do well in mathematics for three reasons.

First, their teacher exhibits qualities of excellent pedagogy. He cares about his students. He is consistent and reliable. He embodies his subject matter: he knows it and loves it. As well, he demonstrates a commitment to mathematics education through his involvement in the math education community. He responds to the demands of the evolving curriculum and to the needs of his students; this is seen in his demonstrations, use of manipulatives and games, his use of math journals, and his focus on practical application of mathematics. He draws from a long history and prepares students for a strong future. Jack Flynn *lives* and *does* good teaching.

Second, the students themselves are, for the most part, from high socioeconomic families where their basic needs are met. These students take education seriously. They know that to do well they must be actively engaged in asking questions. They also know that they are responsible for studying and reviewing the class work. They understand that they must "try hard," take responsibility to "push themselves" instead of "be pushed." And their parents know that the tutorial work that is done at home has influence on the success at school.

Third, Mr. Flynn is fortunate to work with a principal whom he calls "super." He explains,

> I couldn't say enough about Gerry Woodman. The way he works with people brings out the best in them, and, at the same time, let's teachers have the freedom to do what they are best at in the classroom. He is certainly a facilitator. And that makes our job easy.

I observe that the qualities Jack admires in his principal can be seen in Jack, too. As evidence of his own ability to "facilitate," Jack gives students alternatives with regard to problem solving, latitude in choosing their own learning practices, and care for their well-being. I am not surprised to see this self-similarity in Bellcroft School. Perhaps the "golden solution" of which Mr. Woodman alludes is the one we know: *do unto others as you would have them do unto you.* But, at Bellcroft, the rule is a little different: *do unto others as you would have them do unto **others***. Such a rule creates an integrated community. And Jack Flynn's students are fortunate to be part of such a community.

Joyce Mgombelo

Mr. Chieng

I was a bit early with my appointment with Mr. Chieng, when I arrived at B. C school on Monday afternoon. I decided to go to the general office to introduce myself and let Mr. Chieng know that I had arrived. After a phone call, the secretary informed me that Mr. Chieng was teaching and proceeded to show me his room. I then waited until the bell rang and went to the classroom.

The classroom, which was Mr. Chieng's home room, looked like any normal classroom to me. There were desks arranged in rows and a few posters covered the walls of the classroom. The posters conveyed messages about Mr. Chieng's Honor students: stories about the great mathematicians like Newton, Pascal etc. In one of the corners of the room there was Mr. Chieng's table. On it lay a few folders and books. Mr. Chieng was then in his 11th year of his teaching experience. He had taught in this school for 9 years. At that time, he was teaching math 8 and math 9 in both the academic challenge and regular programs.

Students arrived in small groups from their previous class. Mr. Chieng greeted them and made a few jokes with some of the students, "If you can make it here before everybody that tells me something", he said to a boy on clutches. There was a bit of noise in the classroom with students talking to each other and taking their seats in neatly arranged rows of desk. Mr. Chieng settled them by addressing some students by names.

Mr. Chieng and his students had been doing a unit on "Algebraic operations and equations. The week before my visit, Mr. Chieng's students had been learning a new method of solving linear equations. Today, Mr. Chieng and his students would continue to learn this method and use it to solve multistep linear equations. Mr. Chieng had planned to start with warm up equations to remind his students of the method.

Warm up equations

"Let me remind you -- " He wrote on the board three equations:

a) $A = 2\ r^2 + h,\ h$; b) $p = 2(l + w),\ l$; c) $A = bh/2 - 5,\ b$ as he spoke. (figure 1)

a) $A = 2\pi r^2 + h,\ h$

Solution : h : $+2\pi r^2, \rightarrow A$

$-2\pi r^2 \leftarrow A$

$h = A - 2\pi r^2$

b) $p = 2(l + w), l$

Solution : l : $+w, \times 2 \rightarrow p$

$-w, \div 2 \leftarrow p$

$l = \frac{p}{2} - w$

c) $A = \frac{bh}{2} - 5, b$

Solution : b : $\times h, \div 2, -5 \rightarrow A$

$\div h, \times 2, +5 \leftarrow A$

$b = \frac{(A+5)2}{h}$

Fig. 1

As soon as he had finished writing the three equation on the board, Mr. Chieng instructed the students to do the equations *a, b, and c.* "I want you guys to take a minute to do it. All I am doing is asking you to write a formula based on a different letter. I want this one here in terms of *h*; *h* is equal to something," Mr. Chieng said as he was pointed to the first equation. "In this one," pointing to the two equations, "*l* is equal to something and *b* is equal to something. It takes a minute or so. See how much you guys remember from last week's homework." Returning to the first equation again he added, "This one is not bad; start with what happened to *h* and go back. Give it a try."

Some students began to work. But some, like me, were still staring at the board quietly. It seemed to me that Mr. Chieng suspected that some of his students had trouble with the method; so, he offered to do the first equation. "Let me refresh your memory. Last week you remember," he said pointing to the first equation. "The objective here is not to find *A*. We are not interested in *A* anymore. We are interested in *h*. So this way we can easily separate the value of a whole value. So, I want to describe what happens to *h*— what happens to *h* ? So starting with *h*, what happened to *h* ? What happens to my *h* ?"

"Plu-s." Several students attempted to reply.

"Plus the whole thing, which is $2\pi r^2$," Mr. Chieng continued. "We started with *h* and we added something ($2\pi r^2$) here. This sign (positive) is invisible. We know it is possible. The objective is to describe what happened to *h*. *h* is not inside this complex term ($2\pi r^2$). Don't break it down. You are complicating the stuff. What happened? I added something. That's what happened to *A*. Now we go back, starting with *A*. You do the opposite operation. Instead of adding you subtract $2\pi r^2$. That's how we go back to *h*. So you are ready to write about *h*. *h* is equal starting with *A* minus $2\pi r^2$, (wrote on the board $h = A - 2\pi r^2$, fig. 1). Because we go back this way. Now I know what *h* is. This is simple. Once I know what *r* is, I substitute and work it out."

I had been so taken with Mr. Chieng's method of solving the equation that I stopped noticing that students were quiet and concentrating until several students burst out as soon as Mr. Chieng had finished solving the equation, each one trying to say something.

"One more example." Several students exclaimed.

"Hands up." Mr. Chieng requested.

"How do you know which letter to go to? Like how do you go to *h*?" One student asked.

"Clara, you missed the class last week; watch your lesson; do your homework. Last week Clara, we wanted to write the equation based on some value–" Other students interjected by asking questions before Mr. Chieng was able to finish what he was going to say. Once again Mr. Chieng asked his students to raise their hands.

"How did you get minus there?" One student asked while pointing to the negative sign in the solution.

"Because when you go back you do the opposite operation."

"Oh. Okay."

At this point, Mr. Chieng decided to explain again how to solve the first equation to the students. "Let's check it again. I started by h and added something; that's what happened. I added something, nothing else happened, that's how I arrived at A. It is not you who decides what happens first. The equation tells you what happened first. Okay, Clara?"

Clara replied by nodding her head.

Mr. Chieng decided to move on with the second equation. "I am ready for b now." Pointing to the second equation on the board he wrote 'l' underneath it (figure 1). "Okay Clara, describe what happened to l." He looked at Clara for a moment and said, "I added w." He wrote '$+w$,' on the same line and continued. "What happened next?"

At this moment it seemed like Clara was ready, and she replied, "Times 2."

Mr. Chieng wrote 'x2' followed by '$\rightarrow p$' on the board (figure 1), and said, "That's how I arrived to p." Looking around the class he continued, "Okay, I need someone to go back for me. Andy, try that."

"Okay Start with P," said Andy.

"Okay," Mr. Chieng started writing on the right and worked to the left.

"Aah, divide by two," Andy continued.

"Okay." Mr. Chieng wrote '$\div 2$'

"And minus w."

"We are ready for an answer now." Mr. Chieng wrote on the board, $l = p/2 - w$ (figure 1).

"Is it okay if I write $l = (p-w)/2$?" A student sitting at the back of the class spoke up.

Mr. Chieng wrote on the board what the student had just said. "No. It is not okay. Because you have reversed the order here." Mr. Chieng replied while pointing to a line which read, '$-w$, $\div 2$ $\rightarrow p$,' on the board figure 1). "That's why I tell you to learn my method, it tells you what to do with the order of operation."

In the same way Mr. Chieng continued with equation c, with one student doing the describing and the other working backward.

Review questions

After Mr. Chieng and his students had done the warm equations , Joe called for Mr. Chieng's attention. Mr. Chieng approached his desk.

"Can we do this one please?" Joe pointed to a question in the handout.

"That one, aah—that's not today's. Unless you have a specific question." Mr. Chieng asked, as he looked up at Joe. Joe seemed not to be satisfied with Mr. Chieng's reply.

"You want to review this?" Mr. Chieng asked sensing Joe's dissatisfaction. Joe nodded and Mr. Chieng addressed the class. "Class give me a minute. What Joe is saying is this—" He wrote the equation on the board (figure 2).

$$\frac{x+3}{4} = \frac{x-5}{8}$$

$$\text{Solution}: \ 8\left(\frac{x+3}{4}\right) = 8\left(\frac{x-5}{8}\right)$$

$$2(x-3) = x-5$$

Fig. 2

Mr. Chieng looked at the equation and paused for a moment. Then he continued, "This looks complicated. My goodness, what do I do? A–dd 3? Not really. My suggestion is—"

Before he finished his sentence one student offered a suggestion, "Multiply by 8."

"That's right", Mr. Chieng agreed.

As soon as the fractional nature of the equation was removed Mr. Chieng asked students to complete the solution by themselves. Within a few minutes Mr. Chieng continued. "I am on page 49 now. Anything before 49 you want us to do?" Mr. Chieng asked.

"p on page 48", one student offered.

"You are sure about this?" Mr. Chieng asked after he had glanced on the equation.

"Yea." Several students replied.

He then wrote the equation, '*1/x + 1/y = 1/z*' on the board, figure 3.

$$\frac{1}{x}+\frac{1}{y}=\frac{1}{z}, y$$

$$So \ln : y : reciprocated, +\frac{1}{x} \rightarrow \frac{1}{z}$$

$$reciprocated, -\frac{1}{x} \leftarrow \frac{1}{z}$$

$$y = \frac{1}{z} - \frac{1}{x} \text{ (reciprocated)}$$

$$\frac{x-z}{zx} \text{ (reciprocated)}$$

$$y = \frac{zx}{x-z}$$

Fig. 3

"The objective is y–" He paused and looked at the equation on the board. "Now what I described earlier will fail. But not really fail. You have to really know what is happening here." Once again he paused, glanced at the class and continued, "I have to describe what happened to my *y*. I always say plus something, multiply something, subtract something, divide something. How do you write this (pointed to *1/y* on the board). What do we call this?"

"Reciprocal," several students answered.

"So we say reciprocated." He wrote 'y: reciprocated,' on the board (figure 3). "Then what?" Mr. Chieng asked.

"Add *1/x*." Several students answered.

He wrote '+ *1/x*.' "That's how we arrive at *1/z* (wrote '→ *1/z*'). Now let's go back. Starting with 1/z," he wrote, '← 1/z,' on the right again.

"Minus *1/x*", a student offered.

Mr. Chieng wrote '-*1/x*' on the board. "Then what, what is the opposite of reciprocated?" he asked.

A student answered "reciprocated" and Mr. Chieng wrote 'reciprocated' on the board. Looking at what he had written, (figure 4) he continued. "We are ready for an answer now," he said as he wrote '$y = 1/z - 1/x$.' Mr. Chieng then stopped abruptly. Once again he paused, looked at the board and continued. "We have to reciprocate this (pointed to '*1/z -1/x*'). You might as well work this—let's do this—Gee I don't know—We look for the common denominator or something? Let's do it. Watch carefully."

He worked on it while the students watched. Finishing the equation, he sighed, "It is a little bit tough."

Solving multistep linear equations

Mr. Chieng was now ready for his main objective of the lesson; that is, solving multistep equations. "Ladies and gentlemen, we are moving on now. All this was a warm up. We are now actually solving equations. Page 49 solving multistep equations. Let's refresh our memory what is a one step equation."

Mr. Chieng wrote the equation, '$a/5 = 2$' on the board then proceeded to work on it while students watched, figure 4.

$$\frac{a}{5} = 2$$

Solution : $a : \div 5 \rightarrow 2$

$\times 5 \leftarrow 2$

$a = 2 \times 5 = 10$

Fig. 4

He explained why this was a one step equation, "This is a one step equation, one step from an answer." Likewise, he proceeded to demonstrate a two-step equation, figure 5.

$$\frac{a}{5} - 3 = 2$$

$a : \div 5, -3 \rightarrow 2$

$\times 5, +3 \leftarrow 2$

$a = (2 + 3) \times 5$

Fig. 5

"This is a two step equation, two steps from the answer." He explained pointing to the equation. "Let me caution you here, the order to execute the equation. The coma tells you the equal on the calculator. Now we are starting to solve the equations."

He wrote three equations on the board: a) *y/5 + 2 = 12*; b) *(3x + 1)/15 = 3*; c) *6(2y – 3) = 32*, figure 6.

"Don't be afraid because we describe one way and then we do the other way. Some of you guys can just look at it and get the answer. Let's learn the technique."

$a)\frac{y}{5}+2=12$	$b)\frac{3x+1}{15}=3$	$c)6(2y-3)=32$
solution : $y: \div 5,+2 \rightarrow 12$	solution : $x: \times 3,+1,\div 15 \rightarrow 3$	solution : $y: \times 2,-3,\times 6 \rightarrow 32$
$\nwarrow \times 5,-2 \leftarrow 12$	$\nwarrow \div 3,-1,\times 15 \leftarrow 3$	$\nwarrow \div 2,+3,\div 6 \leftarrow 32$

Fig. 6

He then demonstrated the technique for each of the questions asking students to participate. "Joe are you ready for this one (showing c) go ahead. What happens? We are solving for y."

"Times 2, minus 3, times 6 and this leads to 32" Joe said and Mr. Chieng wrote on the board, '*y: × 2, –3, ×6 → 32*' figure 6.

"Good job." Mr. Chieng said to Joe and asked another student to continue. "Erick what happens now?"

"Start by 32," Erick began.

"Okay", Mr. Chieng replied while writing '←32' on the board.

"Divide by 6," Erick continued.

"Equal (wrote a comma)." Mr. Chieng reminded students that a comma means equal on the calculator.

"Plus 3 equal, divide by 2," Erick finished.

"Thank you." Mr. Chieng said to Erick while he completed writing what Erick had just said ($\div 2,+3,\div 6 \leftarrow 32$)

Mr. Chieng spent the rest of the class with another two sets of three equations (figure 7). For each set of the equations he first asked students to try by themselves. "Okay d, e, f is for you. Give it a try." He asked his students to do the first set of equations. Then after a few minutes he solved the equations on the board with some student input. Most of the students were engaged in the activities. I could see them writing in their workbooks. Some were busy calculating the answers from their calculators and contributing them for the class discussion.

$d)3c-15=18$	$e)\frac{7a}{5}+6=10.9$	$f)20-(5+4x)=3$
$g)\frac{-3}{5}(2x+5)=-12.6$	$h)\left(\frac{5x-6}{2}\right)^2-9=160$	$i)26-\sqrt{\frac{n}{4}}=23.5$

Fig.7

The bell rang to signal the end of the lesson. I had been sitting in the class and all I could remember at least for that time was that I had come to be involved with solving the equations myself. I wondered about the method Mr. Chieng had been teaching. It felt very interesting. I had been a mathematics teacher myself but I never thought of solving the equations this way. It amazed me too, that Mr. Chieng had been teaching the whole time. Reflecting back on my experience I wondered what it might mean to teach mathematics?

A teaching style

If one is to look at the previous account of a lesson taught by Mr. Chieng on that particular day, one might notice a sense of familiarity to this lesson. It was a typical math class with the desk-chairs arranged in rows, teacher explaining, use of blackboard, whole class teaching. But to subject Mr. Chieng's lesson to this familiarity might lead us to miss the uniqueness and richness of it. First we might consider the structure of this lesson. Reflecting on the account of my first class visit I see that Mr. Chieng divided the 50 minutes lesson in what I will call short sessions. The sessions consisted of a teacher demonstration of a procedure or technique, a short period of students trying by themselves, and Mr. Chieng working with one student on the board (not necessarily in that order). In the account I gave, these sessions were roughly organized around working on a set of three equations each time. For example, in the beginning of the lesson he wrote three equations: a, b and c. He asked students to try them first. He then demonstrated on the board the first one and solved b and c with some student input on the board. Mr. Chieng describes his teaching as a different style:

> Some people will teach for 15 or 20 minutes, show them a question or two, they copy them and then homework that's it for the rest of class. That's one style. My style is to teach them as much as possible, different variations, different levels of difficulties.

Sitting in that class I was reminded of the days when I was a secondary school student myself. My peers and I had a habit of reviewing from past papers whenever we had an exam or test coming. We would sit in a group and one of us would be writing/solving the problems on the board with the help of other members. In this, there were pauses for the members of the group to think about the problem and then suggest a solution. Of course this does not mean that Mr. Chieng's class was like our group. But certainly there was that sense of group work and participation in Mr. Chieng's class. Everybody in the class would be working on the same problems. Mr. Chieng did not go around to see what students had done or were doing individually. I guess like our group, each individual was assumed to check his or her solution or thinking by watching what was happening on the board.

The remarkable thing from Mr. Chieng's style is that students get to experience three different occasions for learning. First from the teacher demonstrations, second from themselves trying and third by watching their teacher working with one of them.

It is not just this sense of group participation but also the way Mr. Chieng would show the emotions involved in the doing math that is remarkable. Notice for example when he was thinking about the equation suggested by Joe, "This looks complicated, my goodness, what do I do? ..." In this way he is a "colleague," doing math with the students.

Giving something new

Earlier in the account of my visit with Mr. Chieng's class, I said that I was so much taken by his method of solving equations. I went by and shared this with my colleague who became so much interested in the method. Of course, it didn't take long for me to figure out what was going on. A mathematician might say, "An equation like $5x + 6 = 7$ is a statement. Being a statement it tells a story about things. In this case, math objects. It makes sense then to solve the equation by describing what happens to x." However, just because I was able to figure out mathematically what this method was all about, this does not deny the fact that it was new to me and my colleague. I came to learn from Mr. Chieng himself that one of his objectives of teaching is to give his students something new.

> I don't use the textbook notes, because they can read on their own. I want to give them something new, a different angle, so they have another approach to it.

Sitting in Mr. Chieng's class, I was so much taken by the way this method allowed students to talk about solving equations. The language used was very interesting: reciprocated, squarerooted, subtracted etc. For example in one instance students were required to solve the equation $[(3n^2 - 4)/5]^2 - 7 = 0.4$. To describe what happened to n the students proceeded as, "It was squared, multiplied by 3, subtracted 4, divided by 5, squared, subtracted 7 and this led to 0.4. Going backward, start with 0.4, add 7, squareroot, multiply by 5, add 4, divide by 3, squareroot and this gives you n." (figure 8)

$$\left(\frac{3n^2-4}{5}\right)^2 - 7 = 0.4$$

n : *squared*, ×3, −4, ÷5, *squared*, −7 → 0.4

squarerooted, ÷3, +4 × 5, *squarerooted*, +7 ← 0.4

Fig.8

The method provided students occasions to use a calculator meaningfully. As for the example given above they can do the operations on the calculator when they go backward and obtain the value of n. As soon as they get the answer it is possible to check if it is correct by keying back into the calculator from the first description without clearing the answer.

This method is valuable for another reason as well. As I have shown above, this was a method which Mr. Chieng thought of and was well beyond what was offered in the textbook. This sense of "ownership" of the method can be seen in the account of my visit I gave in the beginning. He referred to it as "my method." I think this is a very good experience for students to get to see or experience their teacher's "passion" for doing mathematics.

Planning

On my first visit to Mr. Chieng's class I noticed that students were referring to something which I thought was a textbook. I came to learn later that they were referring to a lecture notes handout which Mr. Chieng prepares yearly.

> What I have here is a whole year's work on notes. I prepare for myself and for the child. Instead of getting the textbook, instead of writing down my notes, it is already typed for them. This way they don't waste time—all the notes are there, all the background

information, all the questions are there. At least I don't waste time in class with me waiting for them to copy notes in which they might have problems reading my handwriting. This is all done for them, they can go ahead, they can look back. They can ask questions ahead of a week especially when they know they are going to be absent from the class (skiing, etc.)

We know that planning is an important activity in teaching. Planning for Mr. Chieng is preparing a handout for his students. The cover page for this handout shows the table of contents which include the topics and unit numbers as shown in the textbook (figure 9).

Note that the sequence does not follow the textbook sequence. Mr. Chieng commented to me that he rearranges the topics depending on a variety factors. Among these factors are: level of difficulty, students needs; e.g.. interest and requirements from math contests. For each topic in the handout there are lecture notes, examples, extra questions and review questions. Mr. Chieng assigns homework from the textbook, extra questions are those which are not in the textbook.

Math 9

Class Lecture Notes

Instructor: Mr. John Chieng

Table of contents

	Unit	*Topic*
1.	*4*	*Rational Numbers*
2.	*2*	*Powers and Roots*
3.	*8*	*Probability*
4.	*6, 12*	*Ratio, Proportion, Percents*
5.	*5*	*Polynomials (I)*
6.	*7*	*Polynomials (II)*
7.	*10*	*Equations*
8.	*9*	*Measurement and Geometry*
9.	*3*	*Transformation*
10.	*11*	*Similarity and trigonometry*
11.	*1*	*Data Analysis*

Figure 9: Cover page for the lecture notes

In the classroom I saw both Mr. Chieng and students referring to the handout. Students could ask questions even those ahead of the present discussion. Recall the situation where one student, Joe asked a review question in my first visit. In other cases Mr. Chieng would refer them back to a previous chapter to recall something. For instance, knowledge about fractions to solve fractional equations.

Planning is also a learning experience for Mr. Chieng. It is not just from the textbooks but from actually thinking of math in different ways.

Mr Chieng comments: "I look at different textbooks and I make my own notes. Besides the textbook might have two or three examples, that's it. My questions are beyond grade 9, because I know there is a gap between grade 9 and 10. I know my students will branch in IB, Math 10, 13, 14 programs, so I prepare them more. I don't teach to the textbook."

This is seen in Mr. Chieng's teaching too. I have already talked about Mr. Chieng's new method. I noticed also that Mr. Chieng would categorize things in terms of difficulty for example. Recall in the my account of my visit he categorized equations in terms of steps (one step, two step etc.). On another day he categorized equations in terms of type one: $2x + 4 = 7$; type two: $3x + 2 - 2x = 1$; type three: $5x = 56 - 9x$. He told students to do type one equations first in an exam or test.

Making stories

On one of the days I was visiting Mr. Chieng's class I had a chance to talk with two girls in the class. It was after the class and the girls were coming for tutorials. I asked them if they liked Math. Both of the girls said, "yes, but only when taught by Mr. Chieng." I asked them what was so special with Mr. Chieng. They told me that Mr. Chieng makes Math fun and Interesting. I asked them to give me an example of a situation in the class when Mr. would make math fun. One of the girls responded, "Instead of saying question p he would say question potato".

As I was sitting in Mr. Chieng's class, I noticed also some instances when Mr. Chieng would "personify" or make stories around his explanations of math. For example in one instance he was talking about the change of sign of a number or variable in an equation when it is moved to another side of the equation. He likened this to changing teams and therefore changing jerseys. He would talk of people in the house and that you have to greet everyone when talking about the distribution of multiplication over addition.

There are many ways one might interpret Mr. Chieng's stories. Humorous might be one way, especially when we think of "question potato". One might also think them as a way of building memory devices for students. By using analogies in students' experiences, they will be able to recall better some technique or fact.

I would also like to think of these stories as ways of giving meaning to mathematics. Of course this meaning is not direct but rather "metaphorical". Think of using no name brand for constant terms in an equation.

In Conclusion

In conclusion I want to point out some of Mr. Chieng's teaching practices. Earlier in the discussion, I mentioned that Mr. Chieng teaches a whole classtime. I noted that his teaching may be thought as a different style in which he divides his lesson in short sessions of teacher demonstration, students working by themselves and Mr. Chieng working on the board with student input. Mr. Chieng plans yearly lecture notes for his students. The lecture notes include notes and questions which are beyond what may be found in students textbook. He also gives his students something new for example a method of solving linear equations which is not in their textbooks. Finally, Mr. Chieng makes stories around the mathematics. For example, he would call terms of an equation in a bracket as people in a house, multiplying something with the terms as greeting everybody in the house.

Eleven

Dover Christian School

"Assisting Students Towards Responsible Learning"

Emile Pinco

The Setting

Dover Christian School is a private Christian school housed in an older school building (circa 1950s). After a humble beginning in which 60 students were enrolled, it has proudly grown to an enrollment of 340 students from kindergarten to grade nine. The entrance to the school is across the hall from the main office, and in the corridor is a display board with information about the school. Also on the board are two photographs of students who had graduated from grade nine last year, each shown receiving an award for academic achievement in their first term of grade 10.

It is Tuesday morning and the school is quiet now except for occasional voices of children from some of the classrooms down the hall. I also see the secretary busy in the office. As I enter, she greets me with a smile and says "You must be Emile." I am shown where to put my coat and briefcase and, since I am a few minutes early I begin looking at some of the information on the office counter. There is a brochure and a student handbook, and I am asked if I would like copies. I discover, that although Dover Christian School is a private school, it maintains provincially approved standards in terms of curriculum and staff qualifications. It also has membership in two associations: the Association of Independent Schools and Colleges in Alberta (AISCA) and the Association of Christian Schools International (ACSI).

Miss May

Miss Linda May is the junior high mathematics teacher in the school. There are two sections of grades seven and nine and one section of grade eight. Linda also has a small junior high science assignment and is Divisional Administrator for the Junior School. When asked to describe the position, she includes jobs such as scheduling, communication with parents, and committee work. When I suggested that this sounded like she was a vice principal, she responded with a shy smile, "Yeah, I guess, kind of."

To get to the class that I am to observe, I must leave the main school building and find one of three portable classrooms. As I climb the steps to enter it, I am met by the English teacher, who is just leaving. I also meet Linda for the first time as she moves from another portable to this one. The portables are quite old, and the entrance to this one is sectioned off by a dividing wall that doesn't reach the ceiling. There are lockers in which students can keep their belongings, and I learn that the students stay in the classroom for most of their classes.

Linda tells me that I may sit at the teacher's desk at the front left of the classroom. It has been turned to face sideways so I can easily observe both the teacher and sixteen students. The room itself is quite traditional: desks in rows, books on built-in shelving along the sides, and motivational posters and displays of student work on the walls. Some students watch me with mild curiosity as I get settled, but they have been told the purpose of my visit, and most students

continue with their five minute break between classes, chatting with each other and nibbling on snacks.

Responsible Learning and Efficiency

"Good morning, how's everybody?" The students quickly move to their desks. There is a short discussion about a hockey tournament and the weekend school ski trip. Although today is Tuesday, it is the first school day of the week. Linda then introduced me and, while she did so, began passing around small orange pieces of paper. A student was chosen to read out loud the "Wise Words of the Week," and I follow along. "A good man thinks before he speaks; the evil man pours out his evil words without a thought" (Proverbs 15:28). Linda asks the class what this message might mean, and there is a brief discussion about how it might relate directly to the students' lives.

Then something happened so quickly that I found myself somewhat confused, but I was most impressed that everyone else knew what was going on. I later found out that each week Linda has a contest called the "Smartie Challenge," and today she was awarding prizes to the winners. The contest involves a variety of things from mathematical puzzles to questions requiring research. This is an optional activity and the prize (a choice selection from the Smartie Bag) is awarded by a draw of entered participants. Participation often depends upon grade level and upon what is involved in the challenge and varies from a few students to more than half of them. The challenge has separate questions for each junior high grade and is also designed to try to involve parents. Neither the student nor parent questionnaires, however, make any mention of this contest.

What is most impressive about the start to this class is the efficiency with which everything occurred. All that was mentioned in the preceding two paragraphs, from the "Good Morning" to the start of the lesson, had lasted a mere four minutes. Little wonder, then, that I somehow had "missed" what the contest was all about.

Responsible Learning and the Lesson Structure

After the girl who won the Smartie Challenge had selected her prize from the Smartie Bag, Linda began handing out copies of the nets, and some students quickly got up to get their scissors. Some students received the net of a cube, others of a rectangular prism or a triangular prism. "Last time, we looked at different formulas for finding area," began Linda as she wrote the title of today's lesson, "Surface Area and Volume", on the board. Underneath the title, she drew various shapes and asked several of the students to give the formulas for each one. "Base times height," said one student for the area of a rectangle as he continued to cut out the net Linda had given him.

Except for the fact that there may be a portion of the lesson given to the taking up of homework, Linda divides her lessons into two parts: an instructional component and a seatwork component. The instructional component includes writing notes and doing examples, both of which are appreciated by students. In their questionnaire to respond to what their teacher does to help them learn mathematics, they said, "She gives us notes, examples, worksheets, and homework."; "She draws pictures to explain." Any part of an assignment that does not get

completed during seatwork time is due for homework. Students have homework about half the time.

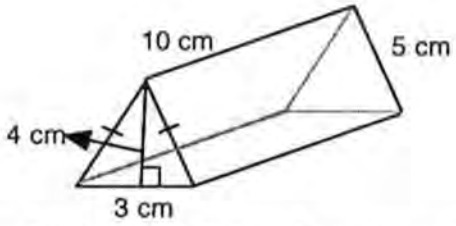
In one of the two lessons that I observed, Linda discussed questions from the homework, in one of them taking about eight minutes of class time doing so. I also noticed that, when the assignment was given, it was not due for a few days. During an interview with Linda, I found out that she almost always gives a few days to do an assignment. The system did not appear to cause confusion for the students. When asked if the students had trouble learning new material after having difficulty completing a homework assignment, she said that, in general, they did not. She explained that the students were expected to use the answers in the back of the book to check their own work and were to ask for help individually if they were experiencing difficulty. She makes herself available before and after school, during lunch and, of course, the students could ask her questions about previously assigned work during class. Occasionally she would look at a question or two with the entire class before proceeding with a lesson even though an assignment was not due for a few days, but she emphasized that this rarely happens.

Responses to student questionnaires revealed a great appreciation for any extra one-on-one help. "If we don't understand, she does it with us, step by step." "She helps you when you need it." "She offers extra help at lunch or after school." "She works one on one with you." "She works with us individually." "She helps us privately if we need it."

Responsible Learning and Interaction

After the brief review about finding the areas of various shapes, Linda wrote the word "Prism" on the board. "Does anyone know what the definition of a prism is?" Linda asked. "Yes, Ron?" Ron then answered, "It's a shape with a top and bottom and rectangles on the sides." "Good" replied Linda, writing a more accurate definition, "a polyhedron (3D object) with two parallel bases with rectangle sides" on the board.

Linda then moved to a student and picked up a folded net that had just been cut out. "What do you think they're asking if you're asked to find surface area? Leah?" "The area of all the different sides altogether," responded Leah. "That's right," congratulated Linda, "a prism is made up of lots of different shapes that we know how to find the area of, and to find the surface area of it, all we have to do is calculate the area of each of those shapes and add them together. Let's do an example."



After drawing this prism, Linda asked, "How do we name this prism?" Some students raised their hands, and Linda called on Jordan. "A triangle prism." "Good," said Linda. "How did you come up with that name?" "You look at the ends and whatever shape they are, that's the name." "Right" praised Linda. She continued, "What would the net of this triangular prism be?" Some students blurt out the answer, "Three rectangles and two triangles." After drawing the shapes Linda asked, "What would the length of this side be?" pointing to the sides of one of the

rectangles. When one student, George, answered, "Five," another student queried, "Why five?" A few other students wondered aloud as well how it was possible that the length of the side could be five centimetres. Redirecting the question, Linda asked George to explain. After everyone was satisfied about the dimensions of the rectangle, Linda moved on to the triangle that represents the back of the diagram. "Dawn, what's the base?" Seeming a bit surprised and nervous, Dawn thought about the question as Linda and the rest of the class patiently waited for her to answer. "Three?" she guessed, and was rewarded with a smile and a "Good job."

The class continued until the surface area of the prism had been calculated, and then Linda summarized, "This is how I want you to show your work. It takes a long time to find surface area, but it really is quite easy." A student commented, "It only takes a long time 'cause you have to write it down, most of it you can do it in your head." Linda made no further comment. Perhaps she had insisted many times before about the value and importance of showing work. In any case, the voice of the student sounded more like an observation than a complaint.

The lesson proceeded in a similar fashion with volumes, first with a definition, then with reference to concrete examples (the textbook and one of the prisms the students had cut out), then a reference to one of the posters on the wall, and finally a worked example. After writing the day's assignment on the board, which would be due for Thursday's class, Linda said, "We have ten minutes left, so you can get started now, and we'll work in pairs this afternoon. Some students wrote the assignment in their agenda books while one girl went over to the side of the room to write the assignment onto a large calendar drawn on the board.

In this brief description of a mathematics lesson at Dover Christian School, we can see many instances of responsible learning. The interaction, specifically, gave the students messages that they are to be responsible learners. First, consider the activity of cutting out the nets of prisms. In fact, for the most part, we might not even see this as a real activity. The nets are passed out by the teacher, and the students immediately get to work cutting them out without being given explicit instructions to do so. Furthermore, Linda does not see a need to give students permission to leave their desks to get scissors, yet, somehow, they are expected to do so without disrupting the class. Finally, students are responsible for cutting out the nets of the prisms while being interactive in a review of the last day's lesson and a discussion about new material. All of this is accomplished with apparent success because the class did not get bogged down. Linda was checking for understanding, and the students began the assignment without a lot of fuss.

The second point worth noting is the manner in which the interaction took place. Linda is certainly in charge of the lesson, directing the discussion very skillfully. Yet there are frequent times when students will blurt out a response, not in a disruptive way, but in a manner which follows conventional rules of conversations. When two or more people are having a discussion, there is not really a leader who gives others permission to talk, yet somehow conversation moves along in a manner which everyone understands. We give each other signals that we have finished what we want to say and signals that another person can now begin to speak. We take turns speaking. In the same way, there was a conversation in this mathematics class. Students were responsible to take part and behave according to conventional customs.

Lastly, it should be noted that students knew that they were responsible for the assignment, and they used techniques to ensure that it would be completed. The use of agenda

books and the side board calendar certainly would assist students to remember to get their work done. During the first few minutes of the ten minutes that remained in the lesson, not everyone started on the work straight away. Some students were sorting out their books, writing information into agenda books, sharpening pencils, or getting some things from the shelves at the sides of the room. Linda did not hurry the students or caution them about wasting time. She began to move around the class helping students as necessary while some students continued to get themselves organized. Within three minutes, all were settled. As Linda continued to circulate, I noticed students waiting patiently for their turn, even going on with another question until she got to them. One student moved to ask another student for help. This caught the eye of Linda who simply continued working with the student she was with.

The class ended with students putting away their books and moving to their lockers and talking. Linda continued working with a student for a few moments. There are elementary and junior high classes in the school so bells are not used since this would cause a tremendous amount of confusion. Students in this class really are given considerable opportunities to take responsibility for their own learning.

Responsible Teaching and Individualization

On my second observation, the class began with a reading from Proverbs and continued with the taking up of questions from the homework. When one student asked about a question involving finding area of a square less an inscribed circle, Linda responded, "Oh, that's a good question! I like that question!" Again, through very effective interaction, Linda took about five minutes to illustrate how to do the question. With no further questions, Linda said, "Lets do a quiz. After the quiz you can work on an assignment until the five minute break." The students did not seem surprised by this. They are either used to getting "pop" quizzes or they were warned in yesterday afternoon's class. The questions were written on the board, and the students quickly took out paper and put their books away without being asked. As Linda wrote questions, students copied the questions down and occasionally asked her for clarification.

After writing the questions, including a bonus question, Linda began to move around the class. If a student had a question, Linda would often help him or her, giving valuable clues. In one instance, a student was led with specific questions to a solution. With another student, she gave a purposeful glance towards one of the posters on the wall. With a third student, one whom I later discovered was on a modified program, Linda selected about half of the questions to be completed.

The message that I got from this kind of individualization is that Linda has an excellent sense of the value of learning. A quiz is not just an opportunity to evaluate students but a valuable learning opportunity. This is, indeed, responsible teaching. A message to students is that they must always be responsible for their own learning—that it can occur in many places at any time.

Responsible Learning and Parents

Ten of the sixteen parents of the students in the class that I observed completed questionnaires, and what is most remarkable is the detail in their responses. While some parents cited their child's ability to "grasp new concepts" as the biggest difference in how well their

child did in mathematics, many parents indicated that they felt that the teacher and her "commitment and dedication" was the biggest difference. They commented on the "extra one-on-one help given when needed" and how she "answers each and every question no matter how trivial." "She has a personal interest in the students." The parent of the student receiving modification also expressed appreciation for Linda's efforts. "My daughter has one-on-one instruction on a fairly regular basis."

Parents also commented on Linda May's teaching strategies, explaining how they felt this contributed to their child's success. "She gives an overview before starting a new concept, and this helps my child." "She can get the point across at their level." "She gives good reviews." "She asks kids to do their corrections and gives extra help if needed." "She explains concepts clearly." The responses on one of the questionnaires were particularly interesting because they were written as if coming from the student. Perhaps the parent completed the questionnaire with the student present. "The teacher explains so I can understand it." "If I fail a test, the teacher will give me a re-write."

Other comments from parents referred to the students' commitment to doing well in mathematics. "My child uses the review sheets the teacher gives him and really looks forward to the question period before exams to help clear up any problems." "My child assists younger children with their work, enabling them to grasp the concepts." "My child reworks problems and keeps up with her homework." "My child goes to a tutor for extra math help after school." The parents also had a consistent definition of successful. "To understand and be able to apply the concept at any time, not just memorizing the formulas or idea." "My child's attitude is a sign of success." "Working hard."

This consistency of messages may be representative of the demographic makeup of the parent population. Almost all respondents indicated that one or both parents had completed university, and half have a combined family income of over $60 000[1]. Because it is a private Christian school, one could also likely assume that many parents hold moral and spiritual values consistent with those of the school. When asked about school-based policies that supported mathematics, one parent pointed out that the school has an "expectation that the children will work to their level of ability." Another parent said, "The teachers take a personal interest in their students and pray for them." Another noted, "Students are expected to listen and focus on the subject being taught."

What these parents are expressing in these statements is their appreciation for responsible teachers providing an excellent education for their children. They also feel that their children are learning to take responsibility for their own learning and, although it has not been expressed explicitly, the message is that parents, as well as the school, are contributing to this.

Assisting Students Towards Responsible Learning

Responsible learning is seen in Dover Christian School many times. The students are given opportunities to become involved in interesting learning situations through the "Smartie Challenge." In the mathematics class, the students are expected to do their homework, to check their own answers, and to seek assistance if they don't understand.

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[1] The principal claims that the average family income of most of the parents is moderate and that many parents make considerable sacrifices to send their children to the school.

They are also expected to be full participants in the class, often doing tasks without instructions. They must be attentive and not disrupt the class as they carry out these necessary tasks. Students are expected to interact during the lesson and are allowed to participate without necessarily being given permission to speak. Students also take it upon themselves to use good time management strategies and stay on task without the need of their teacher.

Linda May teaches responsibly. She uses class time efficiently, ensuring important administrative tasks do not take away from valuable teaching time. Linda also creates a strong student-teacher relationship by getting to know her students and their lives outside of the school. She also makes use of contests and moral messages to strengthen those relationships and create a positive atmosphere in the class. As well, she takes every opportunity for her students to learn mathematics, including quizzes.

Finally, it can be said that parents are making a significant contribution to responsible learning. They are providing consistent messages to their children about the value of taking responsibility for their own learning and providing opportunities for their children's success.

Twelve

Rock Mountain School
A Great Place to Be

Florence Glanfield

About the Community

Rock Mountain is situated about 80 km from a small urban centre. Of the 50 or so buildings right in the community of Rock Mountain, the school is by far the largest. It is a huge single story pristine-looking building, even on this blustery day. There is a place for buses in front of the school and clearly marked parking spots for "staff" and "visitors." The school has a prominent physical place in the community as well as being prominent in the community. The monthly school newsletter serves somewhat as a community newspaper as well. Not only school news can be found in the newsletter, but also news of community events, such as 4H activities.

About the School

I was anxiously anticipating the visit to this school because when I first contacted the principal about this research project, he was very enthusiastic. Frank eagerly agreed to participate in this study and to my visit to both the school and the grade nine math class.

The minute you enter the door of Rock Mountain School, you have a sense that there is 'something' happening in this school. A sign emblazoned with "Rock Mountain School, a great place to be," along with both the principal and vice-principal greeted me as I entered the door. Every entry has two staff members 'posted' to it so that students are greeted as they enter the school building. I think that part of having staff members at the door is also to ensure that students remove soiled footwear as there is carpeting on all the floors throughout the building. At no time in the three days that I visited the school, though, did it appear to me that the staff members were "policing" students; I felt that students were being greeted.

The hallways of the school are lined with inspirational posters about perseverance, courage, and working hard; group pictures of the entire student and staff population; and samples of student work. One of the samples of student work that particularly stood out for me was the huge mural outside the gymnasium highlighting the school team, the Raiders. When you enter the gymnasium, the intense pride in this school is again visible. Banners of sports championships from bygone years line the ceiling and, again, posters outlining the importance of teamwork, hard work, and working together line the walls. I was beginning to feel that this school was indeed "a great place to be."

Rock Mountain School has a population of about 320 students ranging from kindergarten to grade 12. Fifteen students are in grade 9. Although the community of Rock Mountain itself is fairly small, students who attend Rock Mountain School come from a broad geographic region. Some students in this school ride the bus each day for close to one and a half hours one way. Of the ten parents who returned surveys, nine had lived in this area for more than three years.

The staff in this school believe that all students need to be successful in language arts and mathematics in order to be successful in other subject areas. As Terry, the vice principal, told me, "We feel that if you teach the students the reading, writing, and the math, it will help students be successful in high school. Success in all of your high school courses, including social studies, chemistry, biology, and physics, depends upon being able to read, write, and do basic math." Not only that, Terry was quick to remind me that he believes that "math is as important a life skill as language arts." Frank, the principal, expressed a similar attitude. Frank told me that "about four years ago, we decided that we were going to increase the math instructional time to match the language arts instructional time from grade 3 up. This school year is the first year where we've had to cut it back, but we still do have some additional math time over the minimum so our instructional time well exceeds the minimum. We have 40 minutes of instruction a day for the full year, but in addition to that we have one additional class a week, and it's less than what we have had in the last few years, but it's more than some schools." This also means that students in junior high essentially used a complementary course for the additional math time.

In addition to extra time in elementary school mathematics, students are also encouraged to learn to take risks in learning mathematics and to use manipulatives as a tool in their mathematical investigations, in the same way that a pencil or a calculator is used. All of the teacher aides and paraprofessionals who work in the school know, for example, how manipulatives can be used to help develop concepts in mathematics.

Extra time is even a part of the high school program, where a mathematics course is traditionally scheduled for 125 hours. In Rock Mountain School, students who are enrolled in high school mathematics courses have mathematics for 40 minutes every day for the entire year. On every second day, they have an additional 40 minutes. This means that students do not take an elective. I wondered how the high school students felt about this additional time for mathematics. Frank told me that "students here generally finish their high school careers with 110 to 115 credits so the credits weren't really a concern. Secondly, students saw a lot of the elective courses as easy credits and not necessarily really constructive so they didn't really have a difficulty if this was going to help them along the way."

Grade 9 Students

There are 15, ten female and five male, grade 9 students in Rock Mountain School. Eight of the students said that they do enjoy, four said that they sometimes enjoy, and the remaining three said that they did not enjoy mathematics class. All of these students participate in some form of extracurricular activity: school teams such as basketball, volleyball, track and field, or community-related organizations such as 4H.

With three months remaining before writing the achievement test, all but one student responded 'yes' to the question of whether or not they feel well prepared. The fifteenth student responded, "I'll try my best." When asked about what their teacher does to help them learn mathematics, one student said, "she explains concepts, gives guided examples, uses hands on materials." Another student said that she "spends time individually with you if you can't get it [the math]." A third student indicated that "she goes over it [the math] until we understand and shows us more than one way to solve a problem so we can do it the easiest way for us." A fourth student also added that "she encourages us to ask questions." These four students' comments

reflect how all of the students responded to this question. Interestingly, parents responded in similar ways when they identified what they thought made the biggest difference as to how well their child does in mathematics.

Ms. Wright

I am visiting the grade nine math class for three days, Monday, Tuesday and Wednesday. Each math class is about 40 minutes long, and it begins at 9:00 a.m. I arrive a few minutes early on Monday so that I can meet Ms. Heidi Wright, the grade 9 math teacher. Heidi has been teaching six years, all of them at Rock Mountain School. In the past three years she's taught mathematics courses from grade 7 to grade 12. This year, she's teaching grades 7, 9, 11, and 12 mathematics, grade 7 social studies and science, and grades 7 and 8 keyboarding. This is Heidi's second time teaching grade 9 mathematics, the first time being two years ago (Terry, the vice principal, taught grade 9 mathematics at this school for eight of the ten years - *see footnote i*). Last year, Heidi taught grade 8 mathematics so most of the students in Heidi's grade 9 class were in her grade 8 class.

Heidi's classroom, like the school, has a familiar feeling. The walls are lined with posters pertaining to the subjects that she teaches so there is a blend of social studies and mathematics, and encouraging phrases. A teddy bear has a special place at the front of the room. It sits on a chair where all can see it. The teddy bear was a gift to Heidi from students. Heidi has two desks for herself in the room—one near the back and one at the front of the room, facing the desks of her students.

Heidi is a member of the community and was a member before she became a teacher. This means that she often sees her students outside of school time, at the curling rink, at 4H speak-offs, at the store, or at the restaurant.

Heidi herself has an interesting story about mathematics. In high school, she completed the minimum requirements for mathematics. After high school, she worked for many years in surveying before deciding to pursue an education degree. In order to get into the education program, she needed to take high school upgrading courses in mathematics and science at the local college. While taking these courses, she discovered that she really enjoyed mathematics, completed all of the high school mathematics courses, and even took a college calculus course. When she was in the Faculty of Education, though, she decided to major in social studies and minor in French, and when she first became a teacher, she taught grade 1. A few years ago, when the school needed a mathematics teacher, Heidi volunteered. She told me it was because she was tired of teaching social studies and wanted to teach mathematics. I was amazed by this story. Heidi was not sure if she should tell me this story, though, because I might look for errors in "her mathematics". So instead of worrying she came right out and asked me to make sure that I would tell her if I saw something about which she could think.

My Visits

In three days, I had a chance to observe Heidi teaching three times. Heidi and her students had just completed a unit about trigonometry, and on Monday, part of the class time was spent returning the trigonometry unit tests and collecting all of the students missing trigonometry assignments. Then Heidi began the next unit, a unit on powers and roots. She followed the

textbook and had students working with a partner to complete the first activity in this chapter, a feature called Start With What You Know. She told them to take a minute to read the prior page because "it's so cool, I bet nobody knew that" and then to do all of the questions because this set of exercises is a review of last year's work. Students quickly moved into groups and began to work until the bell rang. As students were working on the assignment, Heidi checked individual student work.

Tuesday's class included discussing the assignment from Monday and then developing the ideas around multiplying and dividing powers with the same bases. Wednesday's class started with a 'pop quiz' from Tuesday's ideas following a lesson about zero exponents.

Following my three observations, Heidi and I talked about her teaching practices. In the next few pages, I will share with you my observations of Heidi's classes and Heidi's comments regarding my observations.

Use of Language

I noticed Heidi encouraged her students to talk about mathematics. For example, on Tuesday, when Heidi and her students discussed the assignment from Monday's class:

> Heidi stands at the front of the class, facing her students, and begins to lead the discussion around the textbook exercises. She begins by reading question 1 that asks the meaning of two hundred fifty six to the third power and asks Christine to provide an answer. Christine responds by saying, "It means two hundred fifty-six times two hundred fifty-six times two hundred fifty-six." Heidi asks Christine to carry on to identify the exponent, the base, and the power in two hundred fifty-six to the third.
>
> The second part of the question asks students to use their calculator to find the product of two hundred fifty-six to the third. Heidi asks Mary to give the answer she obtained. Mary says, "I got one six seven seven seven two one six." Heidi asks her to say that as a number, and Mary tries by responding, "Sixteen million seven hundred seventy-seven thousand." Sam quickly jumps in to say, "Sixteen million seven hundred seventy-seven thousand two hundred sixteen." Heidi reminds Mary that she needs to work on reading numbers.

Another example from Tuesday's class occurred after students had generated 'the rule' for multiplying powers with the same base:

> Heidi provides an example where the base is a variable and writes "$x^5 \times x^3 =$" on the board. Tom quickly responds with "x to the power eight or. . ." Heidi completes the sentence with "x to the eighth" [writing "x^8 " on the board]. Stan is watching and then says, "What if you have two different bases?" Heidi writes "$x^5 \times y^4$" on the board, and Selena says, "You just leave it because it wouldn't add up to be the same." Heidi confirms Selena's statement by saying, "Perfect. You would just leave it. There is no combination. It's only if the bases are the same."

While this is occurring, Don is watching and listening and then adds, "Wouldn't it be x seven?" This catches Heidi by surprise, and Don continues "You added x six plus x plus y. So it would be...x six plus y."

As I was listening to Don's comments I realized that he was confusing the role of the 'x's' on the board. He was thinking that the '×' used as a multiplication symbol was the same x that was being used to denote a variable. I was anxious to see how Heidi would respond:

Heidi: No, no. Don't confuse anybody in this room. You can't combine two powers that have different bases. Okay, that's the whole point about it. Because whatever I substitute in for x would work here and here [pointing to the example of $x^6 \times x^2 = x^8$ on the board], and it would equal here. Whatever number I put in there, negative two hundred thirteen, it doesn't matter, if I substituted that in for x.

Don: Yeah, but right there isn't that x to the power six times x times y? So it would be x seven times y?

Tom: That's a times sign, Don, it's not an x.

Don: But if there's no sign it's multiply, isn't it?

[Heidi erases the '×' sign from the expression $x^6 \times y^4$] and says, "Yeah, it's x to the six times y to the fourth, that's what it means."

Don: Okay, now it is.

Heidi: But, but you can't combine because they don't have the same base. These are just rules that have been developed so that's really easy to work with powers especially when you start working with...

Don: But if you have x to the sixth times x equals x to the seven.

Tom: Don, you can't combine them

Students chime in, "Don, that was a times sign, not an x sign."

Heidi: That was a multiplication sign. Okay, notebooks out. Let's get this rule down. Let's get examples down.

Students are expected to keep notes in their notebooks along with their assignments. Students write definitions of the rule of which they have just seen examples; however, additional examples are provided by students to show the meaning of the rule. For example, in the notebooks, students copy from the board: "When you multiply two or more powers with the same bases, you add the exponents."

Heidi's Thoughts About Language

During our conversation about her teaching practices, I asked Heidi to tell me about the role of language in her mathematics class. She told me, "I'm very repetitive in math, simply because that's how we learn any language, you know, from infancy. We learn it by repetition and trial and error and successive approximation and all that stuff so if you keep doing the same thing over and over again, with little increments of improvement every time, you will learn the

language. For example, on the pop quiz today, it was just doing skills, but by about Tuesday the pop quiz will read something like 'Explain to me. . . .' They just have to write something out. I don't do a lot of journaling with them, I do some. I do it on tests and quizzes and sort of informally. I do it talking with them: 'what does it mean when this happens?' and we'll sit, and we'll talk about it for a while. I did journaling last year, the first year I taught the grade 7 under the new protocol, and that class, I tell you, give them one simple little question, you got volumes. They could journal. These guys, they can sure sit and talk, they're really verbal."

Student Involvement in the Lesson

I also noticed that Heidi's students became involved in the development of the lesson. The following example, again from Monday's class, shows how Heidi incorporates her students' voices into the development of the lesson.

> Heidi reproduces a chart from the textbook, onto the white board. She's written $10^3 \times 10^4$ on the white board, and says "I could rewrite this one [pointing to 10^3 with her left hand]. This is what it means. This means ten multiplied by itself three times, right? [writing $10 \times 10 \times 10$ with her right hand]. I'm going to multiply that [pointing to ×] by ten multiplied by itself four times[pointing to 10^4 with her left hand and writing $\times 10 \times 10 \times 10 \times 10$ with her right hand]. How many times is ten being multiplied by itself?" Students chime in "seven." *(The language used here is awkward—others might say this is ten multiplied by itself six times.)*
>
> After providing another example, Heidi encourages her students to generate the rule for multiplying powers by asking, "So what is the rule? What is the rule for multiplying powers?" In unison, students reply with "add the exponents." Heidi again says, "When you multiply two powers with the same base you. . .," and students complete her sentence with "add the exponents."

Again, students would be asked to record the rule in their notebooks and then be involved in generating examples that would support the 'rule' that they had just developed. This action encourages students to talk and think about the mathematics. What I also found interesting was that this expectation of potentially having to provide examples had all students engaged and ready to participate. For example, on Wednesday, Heidi completed the lesson about zero exponents:

> Heidi asks, "So what would the rule be? So you could have any power, any base, how about if we say something like, 'Any base raised to an exponent of zero equals one. [Heidi writes this statement on the board; zero and one are underlined]. Lara, give me an example.
>
> Lara gives the example: $\frac{12^3}{12^3} = 12^{3-3=0} = 12^0 = 1$
>
> Heidi writes this example on the board and then says, "How about an example with a variable in it, Amy?"
>
> Amy gives the example: $\frac{y^3}{y^3} = y^{3-3=0} = y^0 = 1$.

Heidi again writes the example on the board.

Heidi's Thoughts on Student Involvement

Heidi agreed with my comments about student involvement, and again her statement related partly to her beliefs about language and how we learn a language. Heidi also shared with me that she uses manipulatives with her students. Although I did not get a chance to observe Heidi using manipulatives, she said that "I have manipulatives like fraction blocks. I've done a couple of courses on them and, you know, for integers I use poker chips and the alge-tiles for equations and things like that. When Dan [one of her students] did equations with the alge-tiles, he used them right up to the test, but then he decided he didn't want to use them although I said that it was fine if he did. But no, he sort of wanted to do it without these tiles. And he did really really well on it. I just don't use manipulatives often for some kids; most of the kids just don't want to use them when they get at this age. But those that do want to use them really need them and so there again you have to make it okay in the classroom to have manipulatives and to use them. I just tell my students that manipulatives are as much a tool of math as using a calculator. It just doesn't matter, it's just different kinds of tools, and I always talk about the different styles of learning, that we don't all learn the same."

Risk Taking

In my observations of Heidi's classes, I observed that not only were students encouraged to take risks with mathematics, but that Heidi was willing to venture into "uncharted waters." For example, on Monday:

> With about three minutes left in the class, Heidi asks students to use their calculators to perform a calculation and says, "In the couple of seconds we have left, on your calculators do this one, [pointing to the example '$9^{56} \div 9^{43} = 9^{13}$']. Just to prove to yourself that I'm telling you the truth today," and reminds them that "I don't mean do the subtraction. I mean work it out nine to the fifty-sixth divided by nine to the forty-third."
>
> Tim: I got it, two point five four five eight six five eight two.
>
> Jason: That's what I got too, to the power of twelve.
>
> Tim: To the power of twelve?
>
> Heidi displays shock by this answer and asks me to explain what happened with the calculator. I tell her that when the numbers get very large, the calculator will write them in a form of scientific notation.
>
> Heidi: Okay, oh, so this is the answer in scientific notation so then in order to get it into...I have to divide it by the ninth root or the ninth root or thirteenth root.
>
> I tell her it is the thirteenth root.
>
> Heidi: So you got a number grade 9, this is cool. I always wondered why this happened.
>
> On the board Heidi writes 2.5419 12 and says, "So you got a number. So this means two decimal five four one nine times ten to the twelfth (she writes

"2.5419×10^{12} "on the board). That's what that is, the power of ten. The number is too big to be displayed so your calculator does it in scientific notation. So to find out if this is actually going to work, take the thirteenth root of this number." She is pointing to the calculator and then writes the calculator keystrokes on the board (inv y to the x 13 equals).

Tom: One.

Heidi: No, you punched the wrong button. Take this number, go inverse shift, whatever you do on your calculator, y to the x thirteen equals, and you get?

Dan: Nine.

Heidi: Ooh...isn't that cool?

Tom: Why do you have to do it that way?

Heidi: Because this number (pointing to 2.5419 12) is the answer to this divided by this. Its not in powers. This is the actual number.

Tom: How do you know to divide by thirteen?

Heidi points to the 13 as the exponent on the 9. If I take the thirteenth root of that (pointing to 2.5419 12), I should get 9.

Shaun: But we already know it's 9.

Heidi: But if I didn't give you that (Heidi covers up 9^{13} with her hand)?

Shaun: But couldn't we figure it out in our heads?

Heidi begins to explore something on her calculator, but it doesn't work out, and she says, "Oh, you can forget that idea." Just as the bell rings to end the class, another student gets the answer "9" and exclaims, "Oh cool."

A second example of risk taking happened in Wednesday's class. Heidi began Wednesday's class with a "pop quiz" comprised of ten questions, reviewing the previous day's work but also containing two questions that have expressions dealing with the zero exponent. When all the students had finished writing the quiz, they passed their quiz to another student in the class for marking. As Heidi called on students to provide the answers, she wrote them on the board. One question that caused some discussion was $\frac{(-1)^3}{(-1)^2(-1)} =$:

Dan: Zero to zero.

Tom: Wouldn't it be negative one?

Don: Why not zero?

Heidi: Because up here you have $\frac{(-1)^3}{(-1)^2(-1)} = \frac{(-1)^3}{(-1)^3} = 1$. [Heidi points to the numerator and the denominator as she is talking about the solution.]

Don: I thought it would be zero because they would equal to nothing.

Heidi: Yeah, it would. [Heidi erases the 1 and continues writing: $\frac{(-1)^3}{(-1)^2(-1)} = \frac{(-1)^3}{(-1)^3} = (-1)^{3-3=0} = 1$ because she thinks that Don is talking about the exponents.]

Christine: So, if they have negative one, is it wrong?

Heidi: It's wrong, it's one. Don, do you see?

Don: I thought it would be zero.

Heidi again tries to explain that the exponent would be zero and that the reason that the answer is one is because both the numerator and the denominator have the same value. She asks, "How many of you remembered that anything to the zero power is equal to one? How many of you rationalized that this divided by this is equal to one?" and then says, "That's okay, that's okay, I just wanted to see what you guys would do with it."

A third example also occurred on Wednesday when Heidi was working through a textbook question with her students. Heidi said, "Look on page two hundred eighty-four, lots of practice. I want to look at number two here and see if we can work it through. I'm taking a real risk here today doing this."

Heidi's Thoughts on Risk Taking

I asked Heidi to comment on taking risks, both for herself as a teacher and learner of mathematics and for her students. Heidi started, "I was such a poor math learner myself, you know, we are talking the bottom of the barrel. I know that in order to do math you have to feel that it's okay to screw up, and it's okay to make mistakes and to be wrong. I know that there are a lot of different aspects to math and that just because you're not good in algebra, you could just fly through trigonometry or geometry or something because those are such different types of things. I keep telling the kids that I wasn't strong in math, but I had to learn, and I learned through practice. But that's not the complete story of course, you know. What do you do well? Well, I like horseback riding. I had to take lessons and I failed at first. We all have strengths and weaknesses, and we have to keep reinforcing that."

Heidi continues, "The whole thing about risk taking is really important, and it's emphasized all the way through. You know: 'take a guess', 'so what if you're wrong, what's the big deal? Do you think the world is going to quit turning? Do you think that five days from now that it's going to matter if you give me the wrong answer?' You have to try. If you do poorly on a test, so you blew it, you know, fix it. Do something about it. You have the chance between now and two weeks from now to do something about it." She continues about discipline by saying, "That's not to say that it's not important and that we don't discipline, because we do, we discipline. There's a lot of discipline happening and especially with me, I'm not a very gentle disciplinarian. I have a very bad temper so if somebody ticks me, I tend to tip over the edge. So they've learned to kind of walk a line with me. At the same time, they do need to know that it's a safe place to learn."

Other Thoughts

As Heidi and I were coming to the end of our conversation about her teaching practices and what I observed, I asked Heidi to describe her greatest asset as a teacher. Heidi's reply was, "I do a lot of reflection. I don't necessarily write stuff down, but all this stuff is in my head. I think that's what it is, and I think I feel really inadequate as the teacher a lot of the times. Yeah. I do so I'm always worried that I'm not giving the best to my kids. I haven't been well for a couple of years because of this foot. Twelve and a half months, and I've had a cast on for seven of them, and taking pain killers I just feel dragged out. So I really spend a lot of time thinking about my day and, uh-oh, I saw that blank look. At the time you see the blank look, but you are in the midst of something so you keep on going, you go, naw, I saw the blank look so then you have to go the next day and say, 'You look like we were in another world yesterday. Did you get that?' and go back over it, and so I do. I spend a lot of time reflecting."

Leaving Rock Mountain School

As I begin to prepare to leave the school, I wonder what it would be like to teach in such a school, to work with a principal and colleagues who believe that high expectations and standards in the core subject areas are important. A school where, as a staff member, I would know the strengths and weaknesses of all the students, where one of my colleagues would have written a note to the vice principal that started, "I'm concerned about these students' attendance for these reasons," a school where the principal, the staff, and the students believe that it is a great place to be!

Footnote i

For eight of the last ten years, Terry has taught grade 9 math at Rock Mountain School. Terry moved to this school so that he could teach grade 9 math, coach high school basketball, and teach computers. Terry tells me that he enjoys teaching grade 9 math because "it's a challenge, and it's a very important math. I feel grade 9 math is one of the two most important maths in the whole system. There's so much new stuff introduced. It's so preparatory for the high school years. You start to get into quadratic equations, formulas, formula manipulation, integers heavily, and into the start of trig. There's so many things important in grade 9 math, it's a challenge to teach. You've really got to work for it." It is because grade 9 is so important that he also believes that it's not true that anybody can teach junior high math. The administration at Rock Mountain School tries to "get people who have some math background. We may not have math specialists, that's not always easy to get in a small school because everybody has to wear so many hats. But if there's somebody who has some math, we try to put them in there."

Terry believes that students need to practice these new skills a lot so that they can truly be successful the following year. I asked him to tell me about the practice that he does with his students. Terry said, "Students have to have practice. The one thing the program does not give now or does not expect is enough drill and practice with the problems. This introducing concepts for four pages during the year is not enough to teach it and expect them to know. My drill is bringing in extra exercises from other books at the time we're doing it if we have a problem."

Terry also told me that because the grade 9 mathematics course is so challenging for students, he does not always cover every unit. When this is the case, Terry meets with the high school mathematics teacher, and they discuss on which unit or units Terry should place more emphasis. For example, if a group of students is having trouble with algebra, then in order for them to be successful in high school, they will spend more time practicing algebra in grade nine. Terry may redo the unit again, using materials from his variety of grade 9 textbooks.

Marking is also an important part of Terry's class. Terry tells me that "everything we do is marked when I teach math. We mark together. We exchange papers, and everything is recorded. Everything counts towards their marks so they know that if they don't do homework, it's going to affect their mark."

Terry also expects that his students will do their work, and he told me that he always gives his students his home phone number so that they can call him if they have problems with their homework. Depending on the unit of study, Terry could receive 3 or 4 phone calls a night, but there were other times when he would go for a month without a single call. It was Terry's expectation, though, that students would call if they had a question, and "It wasn't a valid excuse to come to me and say, 'I couldn't do anything,' the next day."

In Terry's class, the Grade 9 Mathematics Achievement Test was also the final exam. The students' mark on the test counted 20% of their final mark. If he had time during the school year, Terry might give his students an old test as practice, or he might use a multiple choice test during the year because he believes that it is important for students to at least see the type of test that they will be writing.

Terry loves kids, and he says "If you like kids, you're concerned for what they are doing. If the pay cheque was my only concern then, with my computer knowledge, I wouldn't be teaching. I can make more money out in the computer field than I could here. I like kids. That's why I coach, and that's why I teach."

Thirteen

Oilvale School

Florence Glanfield

Mr. Martin

Oilvale School is located in the community of Oilvale, about 80 km outside of a small urban centre. Along with the school, there are two other buildings in the community, a small store and a house. As I approached the school, it reminded me of my first days in school. Like the first school I attended, almost all of the students arrive at the school by bus.

As you enter the main door of this school, you pass by a set of boot racks overflowing with children's boots. You look ahead and see a trophy case, displaying school achievements over the years. The main door is located between the "elementary end" and the "junior high end." When you stand in the hallway in front of the main entrance, you can see both ends of the width of the school.

I've arranged to meet Mike Martin, the school principal and the grade nine math teacher, to talk about the school and the programs at the school prior to observing his grade nine math class. Mike completed a Bachelor of Education degree seven years ago with a major in physical education and a minor in mathematics and has been teaching math ever since. He has taught it at the grades five to nine levels. This year, he is teaching mathematics and science in grades seven to nine. This is Mike's second year as a principal and second year at this school. Before coming to this school, Mike taught in another small school in the jurisdiction.

We start our visit with Mike giving me a tour of the school. I see all of the classrooms, the library, the computer room/kindergarten room, and the gymnasium. As I was walking through the school, I felt a sense of "family." There was student work hanging on the walls and student-created posters hanging in the gymnasium. Behind the school is a community skating rink—the school's back entry was full of children's skates, just like a family has come home from a skating outing.

Oilvale has a school population of about 90 students and about 8 staff members (including the secretary and custodian). Oilvale has students enrolled in kindergarten through grade nine. There are 26 students in grades 7, 8 and 9. Through grades one to six children are in 'split grade' classes, and when they reach grade 9, they will be in a single grade class. Once students finish their studies at Oilvale they attend a regional high school about 40 km north.

Oilvale School is on a compressed school week. Mike tells me this means that "we get enough minutes in nine days that other schools take ten days to do. So every minute that we count on Fridays, which is every second Friday, we divide that time by two so if you have 90 minutes of math on Friday it only counts for Alberta Education, forty five minutes." This means that grade 9 students will have math for about two hundred seventy minutes a week.

From the first time that I began to talk to Mike about how well students at Oilvale School perform on the grade nine mathematics achievement exam, I've been reminded that students do well, not just because of experiences they have in grade nine mathematics, but because of their "whole school" experience. The strengths in the Oilvale School experience are that children

attend a small school, that the grade nine class is small so each child can receive individual attention during class time, and that teachers and students work together to create a "community" atmosphere. You will see these things reflected in my conversation with Mike. They were also reflected in the comments made on both the parent and student questionnaires. Every parent and student commented on how Mike provides individual attention and does not move on to a new concept until all students understand the previous concept.

Mike's Views About Oilvale School Students' Performance

I asked Mike to tell me why he thinks that students at Oilvale School perform well on the grade nine mathematics achievement test. He told me:

"Students do well on the grade 9 math achievement test because of everything that they learn prior to the grade 9 achievement test. The grade 5/6 class has a really good math teacher who drills their basic facts into them. The junior high has a great students' union with interscholastic and intramural programs that really help round the individual socially and academically. They know all their basic facts so that when it comes time to do the junior high math that involves the calculator you can go on, and you're not using the calculator as a crutch, you're using it as a tool."

Mike adds to this: "There's a great students' union, teachers are involved in coaching the basketball and volleyball teams; and we take the students on field trips. We took them to the climbing wall last Friday, and we did swimming for two weeks. All students go to the swim program. It all comes back to everything we do everyday. It's not just the classroom in math. It might be partially due to what happens in math because, of course, there is learning going on."

Student Support

"Students all feel a sense of ownership to the school, and they all feel they fit in, and they all belong here. For example, this year there was a new girl in grade 9, and she didn't feel like she fit in. The other kids encouraged her to try out for the volleyball team so she tried. She hurt her ankle, but they still really supported her, and then, with basketball, they encouraged her to try again. She didn't, but it's not like she actually gave up, and the other students are saying, "we don't like her anymore." It's like, "Come on, come on over here and try this thing." There's a lot of support from student to student. There's also a lot of encouraging words, and it doesn't just come from me, it actually comes from all of the teachers. Members of the community will also come in and cheer on the kids." I did see one of the basketball games the following day, and sure enough, members of the community were there to watch the students play.

A little later, Mike also added, "Families out here are very supportive. If you have a problem with a student, you phone up the family, and it's like, 'okay, we'll deal with it.' I don't know if it has anything to do with it or not, but most of the families out here are nuclear families. Family values are very strong, and the work ethic is there. You've got a lot of farm kids who have to do their chores."

The Junior High Math Program at Oilvale School

I asked Mike to tell me what he does in grades 7, 8, and 9. "What I've done in the grade 7/8 class is to have a program where I give them the entire unit plan ahead of time, and any

student that had 85% or better on the previous unit can work individually on their own on the next unit. So they may finish two weeks earlier than the rest of the class so it cuts my class size down by a third. Instead of teaching the entire class, I'm teaching two thirds of the class so I'll have five or six students who are working independently. They finish their program or their unit, they get 85% on their test and their quizzes and hand in their unit work to make sure that it's all done, and they get marked on that. If they have 85% or higher, then they get to do a project. The project can be anything they want. I've had some students do research on the special investigative branch of the RCMP, one researched the Titanic, one did a clay model of a friend of hers, one is writing a story, a novel, and what she's done is that she's going to type it out on the computer, and I have another person who's creating web pages."

I was fascinated by the projects so I asked Mike to tell me more about them. He told me, "They are all marked. Students can choose any subject, they could do a play if they wanted to, they could do a gymnastics routine, but it is marked on the subject that they do. So if they choose a social research project, they are marked on social and are given a bonus mark in social. This has already been cleared with all the other teachers. I mark them so it's no extra work for any of the other teachers."

I then wanted to know more about the grade 7 and 8 students working independently. For example, did they rely on their textbook? Mike told me, "They use the textbook, and I'll give the unit plan which consists of the objective which I take out of here (pointing to the curriculum documents). The unit plan tells students what page numbers and what questions to do. This is a new thing so I've put the page numbers and questions in." Mike also told me that he is thinking about making some changes to this in the future. "I'm thinking of putting the objective, and students have to figure what to do and how much they need to do to accomplish that objective. But for now it needs to be a little bit more directed." Mike told me that this is the first year at this school that he is having students work independently; however, he did this at his previous school. Mike also tells me that, because there are only 8 students in grade 9, he doesn't need to have students working independently, and that he has "enough time that I can get to everybody, do everything and take it down to the bare bones."

I asked Mike to describe a "typical" grade 9 math lesson for me. Mike used the current unit of study to describe the lesson. "Powers and roots. We'll just review everything that we've done in powers and roots so far, such as the main rules of multiplying powers and dividing powers, powers of a power, and from there we'll go and do a couple of examples. I'll give some easy examples and some hard examples for students to do. Then we'll go onto something new, and I assign some work. If students are finding the new work too hard, or if they're not ready for it, we'll do examples of the new work the whole time. Then I'll give them a few questions for homework." Mike tells me that, on the next day, he and his class will discuss the homework questions. Based on these discussions and student responses, Mike will decide whether to give students more examples as a class or to assign individual work. If individual work is assigned, then Mike has the chance to work with every student.

I then ask Mike to talk about the role of communication, problem solving, manipulatives, and homework in his classroom.

Mike's Views on Communication

"We'll cover some of those activities in the book like Something to Talk About and Communicating the Ideas if they apply. Some of them aren't that good and will confuse the kids. It's almost like the Extend Your Thinkings. They quite often are to the point where students are not ready for them so we'll go ahead and do the unit and then go back and cover a few. When it's almost to the point where students are just starting to grasp it, why throw something at them that's going to throw them right off? So let students get it, and once that happens, they can go back and do some of the harder things. And some of the objectives, there are some objectives that are not even taught; for instance, the power of a power with similar bases, you add the exponents, but there's no objective. If you have different bases with the same exponent, you can just multiply the bases, and it doesn't say that in the book so I'll throw that in also. For example, $2^3 \times 3^3 = 6^3$, you can multiply the bases if the exponents are the same, and that's not in the book but still something worth while to know if they have to do a simplification or something so I throw a few things in there."

Mike's Views on Problem Solving

"Problem solving, there's a lot of problem solving, and I don't do problem solving every day, but when you get to a page full of problem solving, we cover it, we go over it and do pretty much all of the problems. I do it with them. I'll do one or two and then if I see one that's similar, ahead of time, I'll circle it in my book, and the circle means, "Okay that means they do this one on their own." I'll say, "Okay, try this one." Then I give them a few minutes, and then we'll go over it. One thing that I really disliked as a student when I was in high school, junior high, was the teacher would get you half way through it and say, "Okay, you know what to do, do the rest," and never go back and do it for you. So I always make sure I give them enough time, and then we do the entire question, and we go over it. I'll give them the new problem, and they start from the very beginning. As they are doing it, I'll give them hints: "Okay, remember to do this," "remember to do this," and then we'll go on the board, and we'll do the question.

Mike's Views on Manipulatives

"We're using the math tiles for the integers, and for chapter two, the polynomials, we used the tiles for that, too. And the kids, whether it's too slow for them or something, find them at first fun, but then after awhile it's like, "Come on, let's do the real questions, this is boring now." Maybe I drilled it in too much or maybe I took too long with it or didn't vary the activities enough or something, but they find them boring, basically. The grades 7 and 8 like them still. They still use them."

Mike's Views on Homework

"We don't assign much homework. Kids get it done most of the time. But I'll assign two or three questions, just to reiterate what was done in the class, just to redo what we've done, and because they are so busy, I mean a lot of them help out on the farm, a lot of them are involved in extracurricular activities, and the intramural program. If I fall behind, then they get homework, but because of our minutes we're able to keep ahead. They'll get three, four questions a night or every second night sometimes."

Preparing to Write the Achievement Test

"We do a lot of practice questions. It was kind of hard last year not knowing what would be on it so we did a lot of the cumulative reviews, and we did a lot of problem solving, and they send out some sample questions, and we covered, did all of those, and then we also had a mock test. Basically, I found 50 different questions, and I made it up as a test, and they wrote the test, and they had so much they had 35 minutes to write it, and they had to fill in the dots, and after, when they were finished, turn it over. We modeled the exam. When we were done, we marked it. We went over all of the questions and picked out the trick words in the questions because some of them are tricky. They are not fair questions, and there were a few questions on the test that were very similar to the questions that we did, very similar, they weren't the same but just the way they were worded. They were totally different as to what they were asking, but the way they were worded were very similar. I think that helped a couple of the kids, but being June, I don't know if June is a good time because they are thinking other things. It's not a good time to test the kids and publish all these results on basically 75 minutes of the year." As I reflect on this comment, I believe that Mike is questioning the validity of publishing achievement test results when student performance on the achievement test does not tell the whole picture. It only tells how students have performed in writing that test during the 75 minutes of when it was administered.

Mike's Views on His Teaching

"With math, it's not student directed. It's old fashioned; I stand up at the front of the room and do a bunch of questions and then go around and help them. Seriously, it's the best way, for me. Science is different. Science is a lot more hands on, this is what we are going to do today. Any questions? Okay, read it over, ready, set, go. They'll go off and do it on their own. If they need help, they raise their hands. But math with the grade nines, we've had a few classes where they do their own thing, but mostly it's teacher directed."

We ended our conversation with talking about how students from Oilvale School fare when they attend the regional high school. It seemed to me that they would have a lot of adjustments to make, coming from such a small, family-centered school. Mike told me, "They leave Oilvale with a really good base. So once they get there, they are okay. If you have a solid base and go somewhere else, you'll do fine. Peer pressure might be a thing that affects some of the kids. Last year's group were a bunch of followers so peer pressure is affecting them but not to the point where it's academically. It's affecting them with things like smoking. You'll also get a group that leaves with a good academic base, and because they had the opportunity to play basketball or volleyball, they are feeling pretty confident about themselves so the twist is, they won't be as easily affected by peer pressures as some other students. If we were a larger school, the kids who are not bad players but not really good players wouldn't have made the teams; here, everyone who wants to play gets to play."

My Visit to Mike's Class

One student is absent from class the day that I visit Oilvale. They are working on the 'powers' unit and, I assume, had a lesson yesterday. Today's lesson is somewhat of a review.

Mike starts the lesson by asking, "What is the multiplication power law?"

A girl answers.

"Give me an example," he replies.

Another student responds and the teacher records this on the board, "$3^2 \times 3^5$".

A third student answers, "3^8"

All students agree with the example and the answer.

This same pattern of questioning follows for the "power rule when you divide" and the "power of a power law."

This review takes no more than x minutes, and then the students are given a review sheet that contains 10 questions. Mike advises his students that the review sheet "does not include the hard ones, but it does include the variables" and then asks them for the rules when talking about negative exponents. One student says, "Put it under one," and Mike responds, "Give me an example." The student says, "What's that fancy word that starts with an 'r'?"

As students are working on the review sheet, Mike circulates and works with individuals. One of the students has been away for a few days, so he pays particular attention to her to ensure that she 'catches up.'

Students work on the review sheet for about 20 minutes, and then Mike asks a student, "Are they all right?"

The student says, "Yeah."

"Would you bet your 85% average on that?"

The student quickly responds, "You can give me 30% if I get any wrong."

Mike then goes to the front of the room and begins to discuss the questions on the review sheet. Each student is asked to give the answer to a question and explain why that is the answer. No work is put on the board until the question $(2^5)^{-3}$. The student who is asked to provide the answer responds, "Equals two to the negative fifteen, equals one over two to the fifteen". The student is unable to explain why so Mike shows the work on the board.

The next question is $(3^3)^0$. Another student gives the answer, "Equals three to the zero equals one," and then describes why. The last question on the review sheet is $\left(\frac{3}{4}\right)^{-1}$.

A student says, "Right up front I reciprocated and got four over three."

Another student said, "I did it another way, $\frac{1}{3} \div \frac{1}{4} = \frac{1}{3} \times \frac{4}{1} = \frac{4}{3}$."

The girl that had been away for a few days says, "I don't understand".

Mike says, "You have to flip it—does that help?" She says, "You just don't understand what I'm asking." Mike then leaves the front of the class and goes to help her at her desk.

When Mike is finished working with this student, another students asks, "Does $8^5 \times 2^3 = 16^8$?"

Mike says, "I don't know, I've never tried it—let's try it." On the board, Mike writes out, "$8 \times 8 \times 8 \times 8 \times 8 \times 2 \times 2 \times 2$" and writes, "$16 \times 16 \times 16 \times 16 \times 16 \times 16 \times 16 \times 16$." Students use their calculators to compute the product of each to discover that, indeed, $8^5 \times 2^3$ does not equal 16^8.

Students then made the following comments: "It wasn't hard,." "We should get stickers," "We should get prizes," and "What's so special about variables?"

Picking up on this last comment Mike moves into the final portion of his lesson and talks about generalizing the power laws. The bell rings, and students are dismissed.

My Reflections on Oilvale School

I returned to Oilvale School for a quick visit the following day to pick up student surveys. Mike wanted to know what I had been thinking about after I left the school. I shared with Mike my first two thoughts about my visit the previous day. My first thought was that I really liked the way that students were expected to talk about the mathematics, that this was a safe place for students to use the language they were coming to learn. I also felt that students knew that they would be called upon at some point during the class so felt a sense of responsibility to do the work and participate in class discussions.

My second thought that I shared with Mike was that I was thinking about the power law that he described as, "When you have different bases with the same exponent you can just multiply the bases." I was left thinking about that law and told him that I had never heard of it before but that I did understand the derivation. Mike had, in some way, made the Powers and Roots unit 'his own' by introducing students to this law.

I did have a chance to watch one basketball game, and it was very exciting. Oilvale's girls' team did win and to celebrate with them were their school mates, their teachers and people from the community. Once again, it reminded me of the school that I first attended—all the children knew one another, the school building was a central focus in the community, and support for all of your efforts were provided by both your peers and teachers. There was a sense of "community" at Oilvale School.

Fourteen

Cameron Catholic Junior High School

Joyce Mgombelo

Cameron Catholic Junior High School is located in one of the major school districts in Alberta. The school is attended by almost 400 students in grades 7 through 9. The school building and its athletic fields sit in a quiet middle class neighborhood. The school draws students from a variety of backgrounds and races. There are 18 teachers in this school.

There are a number of possible reasons for the success of Cameron Catholic Junior High. One of them is the extra instructional time that the school offers in junior high core subjects. In the case of mathematics, the school offers 158.5 hours of instruction in each of the grades (7, 8 & 9) per year, well over the Alberta Education requirement of a minimum of 100 hours per year. Also, Cameron Catholic Junior High places emphasis on the core subjects (mathematics included) and, therefore, offers a limited number of complementary subjects.

Evaluation of students' work is valued as an ongoing process at Cameron Catholic Junior High. Evaluation is seen as an integral part of the learning process. The school issues computerized report cards four times a year: report 1 in the middle of November; report 2 at the beginning of February; report 3 in the middle of April and report 4 at year end. Students receive two report cards each reporting period, and parents sign one and return it to the school. Also, the school organizes conferences for parents and teachers following the first and second reporting periods. Cameron Catholic Junior High recognizes academic excellence and offers awards to students. One of them is the "Honors" award. An honor is achieved by a student who obtains an 80% average in the core subjects (science, math, social studies and French) and a rating of satisfactory or minimum of 65% in physical education, religion, and all other complementary courses.

Most of the students at Cameron Catholic Junior High follow the regular program. In addition to this, the school offers the Accelerated Placement Program, (APP). APP is designed for academically talented students. APP students develop their talents in the areas of mathematics and/or science. They are integrated with other students for all other subjects. It is not only the academic talented students needs which are taken care of but also the needs of students who have academic difficulties. The school has resource facilitators, certified teachers who work with students experiencing academic difficulties. Services may be provided within their classroom or on a pull-out basis. In addition, Cameron Catholic Junior High offers the Study Buddy Program. The program pairs those students who are experiencing difficulties in their school subjects with education students from the University of Alberta who provide one-to-one tutoring.

Mrs. Weslosky

Mrs. Weslosky's home room was on the second floor of the school building. The room had windows on one side of the room facing the athletic grounds. There were two boards on the walls of two sides. The wall at the back of the room was covered by geometrical models which Mrs. Weslosky's students made during one of their projects. The models were colored very

artistically and they looked very attractive. Mrs. Weslosky's desk was positioned in one corner in front of the room. On it there were several folders, books, and a computer.

Mrs. Weslosky's teaching load at Cameron Catholic Junior High included Math 7, 9, 10, and Information Processing 9. She had earned her teaching credentials in 1974, graduating with Bachelor of Science and Bachelor of Education degrees. Her major subject was math, and German was her minor. This was her 24th year of teaching experience.

Small groups of students came in through the door in one corner of the room. Mrs. Weslosky greeted them happily. Students took their seats in the desk-chairs. These students were remarkably quiet with joyful faces. At the time of my visit, Mrs. Weslosky and her students were working on a unit on Transformations. They were using "Math Power 9" as their textbook. They had covered the three transformations: translation, reflection and rotation. Today, Mrs. Weslosky had planned to review homework on rotation (*Math Power 9*, pg. 307/308) she had assigned to the students the week before.

Mrs. Weslosky introduced me to her students and proceeded with her lesson. Before going through the questions, she asked her students to first review the importance and properties of a turn.

Review on Rotation

"Last week we talked about the turn, and we had a couple of pages of assignment. Let's review first of all the importance of the turn and its properties. For the turn, there are four things that we need. Which is one of them? Could someone raise their hands and tell me?" Several students raised their hands. Mrs. Weslosky addressed one of them. "Okay, John."

"Turning point," John offered.

"Turning centre. We have to know around what point we perform a turn. What else do we need, Mary?"

"Original."

"We need something to turn, and that's the original. In every case, we have been turning something like a line segment, triangle-- What else do we need, Sam?"

"Turning arrow."

"Right. We have to know what direction to make the turn. What else?"

"Image," one student offered.

Mrs. Weslosky continued with this line of questioning. "Now as far as properties. What did you notice about the original and its image? What is the property? Do you remember anything special about the original and its image?"

"The original and image have the same size and shape," a student answered.

"If you turn something it does not change its shape or size. Sometimes depending on where the turning centre was, the original and image may be overlapping," Mrs. Weslosky offered and then instructed her students to turn to page 307 (*Math Power 9*) for the questions.

"We now know the property. How do we perform the turn?" She drew an example (fig. 1) on an overhead and continued to speak while she was drawing. "Here is x and y. Here is my original. The origin is going to be my turning centre, and I want a quarter turn counterclockwise." She then called one student to come and do the turn on the overhead.

"Bill, how do I perform the quarter turn counterclockwise?" Bill came to the overhead and drew the image on the grid transparency (fig. 1). Mrs. Weslosky continued to probe from Bill. "How did you do it? Did you do your homework by tracing or what?"

"By just looking at it." Bill answered.

"Maybe we should mark that turning centre. What do you think about that?" Mrs. Weslosky suggested to Bill. "Okay, is that a quarter turn counterclockwise? How can we be sure that it is a quarter turn?"

"We know it is 90°."

"We could also do what-- Okay, thanks."

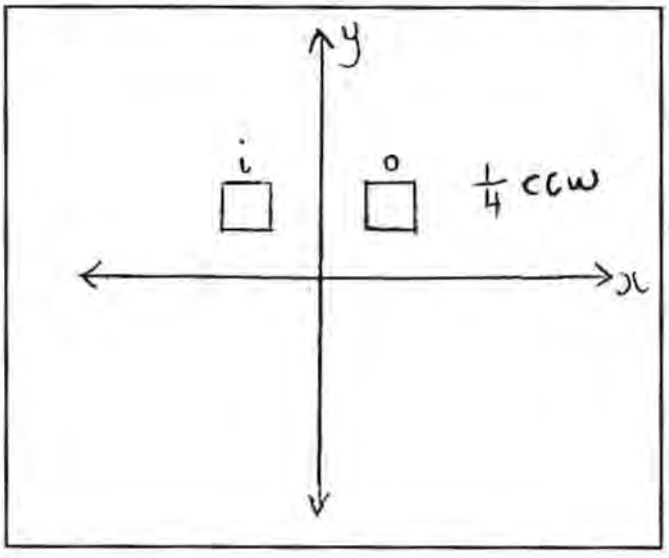

Fig. 1

Bill went back to his desk, and Mrs. Weslosky continued. "If you are-- not only trace the original, you need to trace the turning centre. It is also helpful if you can trace the turning arrow as well. If you trace that, you say okay, I am going to turn the pointer, and I am turning. Then, I am going to reline up my centre, and I am going to see how I can perform my counterclockwise turn. How many people did most of their homework by tracing? " Very few students raised their hands. "How many did it by looking?" More than half of the class raised their hands. "Some of you did a combination." Then Mrs. Weslosky shared her experience. "As I was doing it myself, I had a hard time looking at it. Like this one (pointing to diagram on the overhead, fig. 1), I could see without tracing. When you are getting to some of these like number 12 (*Math Power 9*, pg. 307), I would have a hard time just doing it. That's why I will use a tracing paper."

The assignment

At this time, Mrs. Weslosky decided to move on to the assignment. "Okay. Let's go through the assignment then, pg. 307 (*Math power 9*)." Students opened their folders and their textbooks. "Question 1 to 6, the answers were given at the back. So all you have to do is to refer to these answers. So, were there questions on numbers 1 to 6?" There was silence in the classroom, and I think Mrs. Weslosky took the silence to mean that there were no questions. She then continued, "Okay, let's go through those. Which answers were not given at the back-- there were actually diagrams." She proceeded to demonstrate the solutions using the overhead, each time pointing at the diagrams drawn.

"So the first one is number 7. You can see the original in blue and the image in red. This was 180° clockwise turn. What other turns are equivalent to 180° clockwise turn?"

"180 degrees counterclockwise." One student offered.

"So if you have to do 180° clockwise, it is the same as 180° counterclockwise. Okay, the next one is number 8. This is a triangle. This one you are supposed to do a 90° counterclockwise. And there you could see the original in blue and the image in red. By the way, a 90° counterclockwise, Mike, will be the same as what?"

"270 degrees clockwise," Mike answered.

"Exactly. A 90° counterclockwise is the same turn as a 270° clockwise turn. Is there anyone who doesn't understand why that is?" No student indicated that he or she didn't understand. "Okay. Number 9 we have this geometric figure, and we are supposed to do a 90° clockwise. The turning centre was indicated there. So the original is in blue and the image in red pen. Okay, number 10 (fig. 2) is the one which a lot of people get wrong unless they trace. The turning centre is one of the vertices. So when we turn, it is not going to align exactly. Any questions, comments on that one?" There were no questions or comments from the students. I could see that most of students were quite engaged with the activity. Most of them were busy looking up to the overhead and down to their work.

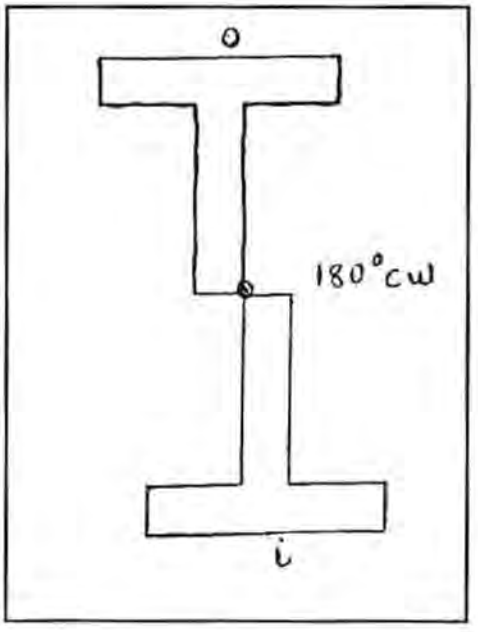

Fig. 2

Mrs. Weslosky continued with the assignment. "Okay, number 11 is one where the image ended on top of the original. Now this rectangle, the turning centre was the origin, and you are turning 90° clockwise. You can see the image in red and the original in blue. Any comments or questions? How many people have this one correct?" More than half of the students raised their hands. "Okay, number 12, same idea. Triangle. This time 90° clockwise. Turn centre origin. Original in blue, image in red. 13 same turn and 14 right here. Turn centre here. Quarter turn. Every one is okay with these?"

"Yeah." Several students answered.

"No. 15 we are doing 180° counterclockwise which is the same as 180° clockwise. So, 15, here is the original in blue again and the image in red. With myself, I find it a lot easier with the 180°. I don't need to trace. 16 is there, 17 and 18 right here. Everyone is okay with those?"

"Yeah."

"Okay, 19 you were given a triangle with specific vertices. The vertices are at the origin, (0,6) and at (–4,2), and you are supposed to do a 90° counterclockwise. So you could just do the 90° turn with the vertices and then join the vertices of the triangle, or you could trace it. So any questions or comments with that one?" No one had questions or comments. "Okay, any questions or comments on 307?" Mrs. Weslosky asked and moved on to page 308 (*Math Power 9*) after being convinced that there were no questions on pg. 307. "Let's continue on page 308, and these are problems that are on applications. Okay, 22 the original is there on the right and the image of 90° counterclockwise turn is in red. My 23. The first time I did it, I did it incorrectly. I did it like a reflection, and my image was here (Fig. 3). And then I redid it and said this is it. How many people have this one correct?"

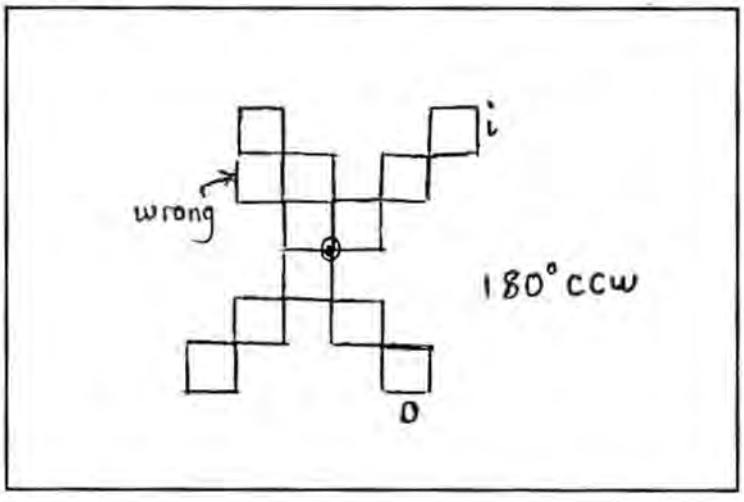

Fig. 3

A few students raised their hands.

"See. A lot of people did the same as the first time I did. You can't see it. Use the tracing paper. This one is hard to see. Okay 24 to 28, the answers are given at the back. Problems or comments on those?" Nobody had questions. She continued. "Okay, let's do number 29. You are supposed to locate and do a 180°counterclockwise turn. The origin is a turning centre. Here is the original in blue and the image in red. Number 30 is the same right

here. You were given the vertices of a parallelogram. And you are supposed to do a 90° clockwise and origin as the turning centre. Here is the origin in blue and the image in red."

At this moment, Mrs. Weslosky decided to find out how students were doing with the unit. "How are you people enjoying this motion geometry? Is it a nice change from measurement and algebra?" she asked her students. There were a number of responses from the students, most of them indicating that they were enjoying the unit. Some students nodded, some said something like "Yeah." To this she responded, "I am glad that you are enjoying it."

Mrs. Weslosky moved on with the assignment. "Okay, number 31 there are two parts to it. The first part you are supposed to use one of the vertices as the turning point. The image is here in red. Taking the same thing now with the origin as the turning centre, there, is the image in red. Okay, 32. This one I have colors switched around. The original is in red. The turning centre is at S. The image is in blue. And this one was a 90° clockwise."

She continued. "Okay, 33. The answers are given at the back. Does anyone have a problem with the answers?" Nobody seemed to have a problem. "Number 34, I don't have a transparency of it. But the answers are at the back. Everyone is okay with that one?"

"Yeah." Several students answered.

Plotting Graphs

Mrs. Weslosky suspected that most of the students would have some difficulties with number 35. "Okay. How many people didn't do number 35?" Most of the students raised their hands. "So I figured." Mrs. Weslosky commented and continued. "Number 35, we are going to do it right now. It says plot the line $x + y = 2$ on the grid. Well. You did not do this type of work this year yet. But I know you did it last year. So first of all it tells us when I plot this thing it is going to be a line. I know I have to end up with a line. What do I have to do? Remember not long ago we were solving equations that have one variable; for example, $4x - 11 = 13$. How many values of x did we have?"

"One value." A student answered.

"What about $x + y = 2$? How many values? 1 and 1, –1 and 3, 99 and –97. How many?"

"Lots." Another student offered.

"Actually an infinite number. Let's now find the table of values (Fig. 4). Sandy give me one."

"1 and 1"

"Kim. Another one."

"0 and 2"

"It is actually nice to get some negative values. Ken, can you give me negative values?"

"–3 and 5"

x	y
1	1
0	2
–3	5

Fig. 4

"Take the three points and plot them. Those three points should give you a line. If you don't get it, there is a problem." Students started working on the line. Mrs. Weslosky was circulating around the class watching what the students were doing. She noticed that some of the students were plotting the points without drawing the x and y axes. She went to the overhead and demonstrated how to plot the points herself.

"Some of the people are plotting the points on a grid without the axes. You need to have the x and y axes and the origin (she drew the axes on the overhead)." Plotting the points she continued. "Okay, those points should be on the straight line." Drawing the line through the points she proceeded. "Now when I draw I don't stop at the point. I put arrows at each end of the line. What do those arrows indicate?"

"It goes forever." One student answered.

"Right. What else do I have to do? Rose, read the question for us."

Rose read the question (No. 35, pg. 308, *Math Power 9*). As soon as she had finished reading, Mrs. Weslosky continued. "Okay. We plotted the line. Can we rotate it then? Rotate this line 90°clockwise using your origin as your turning centre." The students started working, and Mrs. Weslosky did the same on the overhead. Then pointing to what she had just done, she said, "Okay, did you get this as your image? Show me, and I will look at it." She started circulating around the class. She seemed to be satisfied with her students' work. She was now ready for question number 36.

"How do you go about doing this table of values? How did we do the other one? We said, 'Well I know the numbers that add up to two,' right? How do we do this one, $y = x - 3$? Can someone suggest how we do the table of values?"

"Put x on the other side," a student suggested.

"So we will have $x = y + 3$. Or you can say choose an x value and substitute it in. Say $x = 1$. What's 1 minus 3?"

"–2"

"–2. Right. So choose any three numbers you want for x and substitute in. You get the corresponding y values. When you get your three points plot them. Make sure they lie on a straight line. Use a straight edge and put arrows on them. And stop there." She went around the class and decided to demonstrate again on the overhead. She asked some of the students to give her their points. "Cathy, give me one of your points."

"0, –3."

"Cindy give me another one."

"3, 0."

"I said we need at least three points. Let's have another one. Another point where x is negative."

"–3, –6," one student spoke up.

"So let's plot these points then and see if they lie on a straight line. Again, in order to plot the points we have to draw the x and y axes. You can't just draw or plot points somewhere under the graph paper. When you build the table of values, build in order of x first and then y. That's how we graph the points. That's why they call them ordered pairs. There is a certain order that you graph the points. You start on the origin then you go right or left depending on the sign of the x value. T hen you go up or down depending on the sign of y value. Tell me how to locate (0, –3)."

"Go to the origin. And then 3 steps down," a student offered.

"And how do I locate (3, 0)?"

"Go to the origin. Then three steps right," another student answered.

"What about (–3, –6)?"

"Go to the origin. 3 steps to the left and 3 steps down."

"So I plotted my points, and you can see it is a straight line. So now what am I supposed to do with this line? Rotate 180 degrees about the origin. I am going to draw 180°. So I trace it here. I go 180 degrees. What do I have?"

"Parallel line," one student exclaimed.

"I have a parallel line, exactly."

"So there is my image. Are they related? Well, they are parallel."

Mrs. Weslosky instructed her students to do the rest of the assignment in the same way. She then demonstrated on the overhead with student input. Finally, she closed her lesson and reminded students of what they were going to do the next day.

"That is the end of the assignment. Unfortunately, there is not enough time to do something new. How many of you did your test corrections?" Most of the students raised their hands. "We are going to do them tomorrow," Mrs. Weslosky finished.

Mrs. Weslosky's Teaching Practices

Patience

It is very common to hear from some teachers that they are pressed for time to cover the curriculum in their classes. Very often, these teachers would rush their students to finish their work and ignore those students who are not yet done. This was different with Mrs. Weslosky. In all her classes I visited, there was no indication whatsoever that Mrs. Weslosky worried about time. In fact, I was so amazed the first day the way Mrs. Weslosky took the homework for the whole class time. She made sure that she went through each question. Each time she took time

to know if any of her students had a problem. Even with those questions which she thought didn't need much concentration, she would ask students if they had questions or comments.

In response to the questionnaire question, "What does the teacher do to help your child with mathematics?" one parent wrote, "The teacher is organized and thorough. She explains every new concept step by step-- slowly. She gives comprehensive notes with many examples and gives extra worksheets and verbal explanations to students who need it. She has a great deal of patience." Mrs. Weslosky has a great deal of patience. She is a teacher who will take time for the sake of each of her students. In the class, I noticed that as soon as she found that a student had difficulties with something, she would not give up on him or her. For example, at one time a student had a problem with plotting points. She helped him until she was satisfied that he was able to plot the points. Even in the account I gave in the beginning, one could see Mrs. Weslosky's patience. When she found out that her students had problems with graphing lines, she took time to teach them.

Most of the students acknowledged Mrs. Weslosky's patience in response to the questionnaire question, "What does you teacher do to help you learn mathematics?" Some typical responses were: "very patient - she makes you feel confident; reasonable exams with plenty of time; goes over homework; sometimes reassigns homework for better understanding; makes sure you understand before moving on; goes over any questions that are asked." My experience with Mrs. Weslosky's class taught me what it means to integrate assessment with the teaching and learning processes. One student pointed out that "Mrs. Weslosky gives quizzes to see if you understand." In the class, I was able to see the way she reviewed homework and tests. It is not just showing correct answers but also being informed of students difficulties and acting on this information. When she learned that her students had problems with plotting graphs, she taught them.

Clarity and organization

As an example, let us follow what happened on one of my visits to her class. On this particular day, she had planned for her students to do an activity on tessellation. First, she made sure that resources for the activity were available.

"I mentioned that we will be doing something related to what we've been doing. You are going to have chance to display your imagination and your artistic talents. This morning I asked you to bring pencils and crayons. I have some of those you can use. You may need geometry instruments. You need scissors, and I have scissors. Now what we are going to do is something that is called tessellation."

Second, she read with the students about tessellation from the textbook (*Math Power 9*, pg. 318). She asked one student to read while others followed and commented on important points. "Remember when you are designing the tessellation, it has to cover the page. There can't be overlapping spaces." She commented on one instance after the student had read from the book. She had planned on using the idea of activity 2 and 3 in the book (*Math Power 9* pg. 318). She asked one student to read about these activities.

Third, Mrs. Weslosky wrote instructions on the board (fig 5) and explained them. "I am going to explain what I want you to do. First project, I want you to start with a square or parallelogram. When you do this, you may use a graph paper. And I did photocopy some graph

papers. If you want, you can have them. And I photocopied some draft papers. You are welcome to use some. And then I want you to alter one or two sides. Then you are going to tessellate this, color it, and give it a title." In the same way, she explained about project 2.

Fourth, she demonstrated with an example. "As far as how to do it, you people are going to be your own engineers. But I am going to show an example (fig. 6). I started with the square. I made an M and then cut it and slide it on the top. So then I trace it."

Activity: You will make two tessellations:

1. Using a parallelogram or square

A. Alter one or two sides

B. Tessellate the plane by sliding

C. Color; add patterns

D. Give it a title.

2. Using another shape such as a hexagon, triangle or rectangle

A. Alter two or more sides

B. Tessellate the plane by sliding or turning

C. Color

D. Title.

Fig. 5

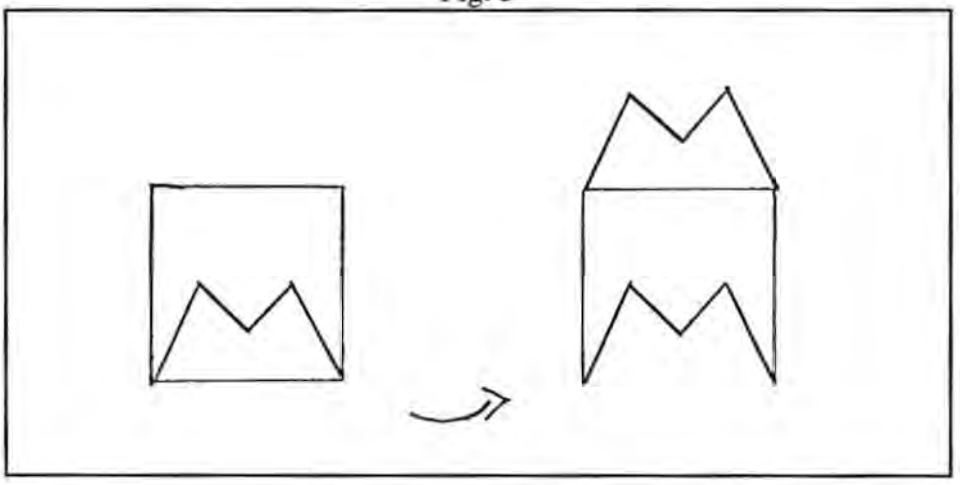

Fig.6

Fifth, she had planned for her students to visit another class that had done tessellation to see examples on the wall. When students returned from their visit, she discussed with them about what they had seen. Students began to work, and by the time the bell rang, most of them had done activity one. Mrs. Weslosky circulated around the class, offering help and advice where it was needed.

In addition to patience, Mrs. Weslosky is very clear and well organized whether it is in her explaining of math concepts or giving instructions to the students. She speaks audibly and slowly in the classroom. Parents seem to acknowledge Mrs. Weslosky's clarity, too. Earlier, I discussed some comments from one parent in a questionnaire. This parent commented that Mrs. Weslosky is organized and thorough. She gives comprehensive notes with many examples and gives extra work sheets and verbal help to students who need it. Similar comments were indicated from students' responses to the questionnaire questions. Comments such as "she explains clearly, uses examples, drawings, and charts, uses visuals" were common.

Embodying the discipline of mathematics

It is not strange in some mathematics classes to find students drawing lines by hand, or sometimes drawing graphs on plain paper. Mrs. Weslosky is very careful with things like this. She makes sure that her students use appropriate instruments and resources to do mathematics. If it means plotting graphs, her students will have graph papers, sharp pencils, etc. If it is drawing lines, students have to use straight edges. It seems to me that students in Mrs. Weslosky's class are used to this type of discipline.

There are other ways in which Mrs. Weslosky encourages her students to value the discipline of mathematics. Consider an instance where she was explaining how to build a table of values for a graph. She insisted on the order in which the table is to be built, starting with x values and the y values. She also showed the order of plotting the points and explained the significance of this to the notion of ordered pairs.

Another example can be seen at the beginning of the class account I gave. She was going to review the homework, but before she could do that she reviewed the importance and properties of the turn. She also discussed how one would go about performing the turn. She pointed out the terminology used as far as the turn was concerned: for example, turning arrow, image, original, etc.

When it comes to doing mathematics, Mrs. Weslosky demonstrated to her students what it means to do mathematics. She shared with the students her experience of doing mathematics. In one instance, when she was reviewing the homework, she showed her students how she had done one question (no. 23, pg. 308 *Math Power 9*) incorrectly and how she came to correct herself. She also shared her difficulties in visualizing some of the turns and her preference for using a tracing paper for these turns. One could interpret this as modeling mathematical behaviour. I preferred to see this as embodying the discipline of mathematics. Mrs. Weslosky showed her students what it means to do mathematics. It is not just doing it correctly but also making mistakes.

In Conclusion

In conclusion, I would like to repeat the comments of one parent: "[Mrs. Weslosky] is organized and thorough. She explains every new concept step by step -- slowly. She gives comprehensive notes with many examples and gives extra work sheets and verbal help to students who need it. She has a great deal of patience." In addition to this, Mrs. Weslosky demonstrates to her students what doing mathematics means. Finally, one does not do all of these things without caring for students. Mrs. Weslosky cares for her students.

Fifteen

Wayside School

Rick Johnson

Mr. Smith

Seventeen grade nine students are fully attentive to the examples being drawn on the chalkboard. On every desk is an open Mathpower 9 *textbook, a binder of loose leaf paper, and a calculator. The formulas for 'sin,' 'cos' and 'tan' have been recorded on the chalkboard from student recall of last day's lesson. A sample triangle is recorded on the board with hypotenuse, adjacent, and opposite sides labeled. The phrase SOHCAHTOA figures prominently. All of these drawings and labels form the reference material for today's practice questions.*

"Write this down," Mr. Smith says as he draws a triangle with an angle labeled x, hypotenuse "8", and adjacent line "6." He moves quickly and deliberately, calling out each item as it is drawn. He is alternately offering ratios and angles from his own use of a calculator and calling out for information from students.

"All right, I have a triangle here with this information. What have I got? What do I need to find out? Remember, I want to see the ratio."

Students quickly offer answers and the pace remains brisk. Until one student asks, "Could I find the sin?"

There is a silent pause as Mr. Smith looks up at the student. A sincere question, reflecting the student's reasoning concerning what might be the best way to solve these problems, but also a stall in the otherwise smooth flow of examples and solutions. After a second or two of thought, Mr. Smith does answer the question directly. He offers a method of solving using the student's suggestion, but also clearly explains the advantages of choosing the one formula that requires only one calculation.

This is a telling moment. It is clear that Mr. Smith wanted to conduct a straightforward and smoothly paced review of content taught in a previous lesson. As often happens, one student has had time to reflect on the concept and has begun to question the how and why of the routines. His question is given serious attention and stands out as one example of the way that teaching and learning was observed to be tailored to the students at Wayside School.

Class Nine B was observed over a period of three days. The topic being presented and reviewed was trigonometry. The lesson sequence was as follows:

- topic introduced and concepts taught: This class was taught on Friday and was not observed in this study.
- teacher-led practice of the concept: This was a double period of eighty minutes on Monday during which the concepts were reviewed and practiced. This was the first class observed for this study (Observation Day One)

- student independent practice with the concepts: Students worked through practice questions from their textbook. (Observation Day Two)
- quizzes: Twelve questions were presented on the board; marks were recorded. (Observation Day Three)

Observation Day One:

There are seventeen students present this day, including four who missed the introduction to the concepts on Friday due to a field trip. Mr. Smith is interested in how well they will do today, but is confident that they will pick it up quickly. In an aside he explains that they are four of the most able students.

The room shows almost no evidence of mathematics teaching or learning. Posters, models, chart paper and notes on the boards all reflect language learning, science, and health topics. It is later explained that this is Nine B's homeroom and the place for the teaching of all their core subjects. To minimize traffic problems in the hallway, the school administration has asked that the teachers come to the grade nine classes in their rooms.

The students are returning to the room from lunch break, and one student reminds another that "This is Mr. Smith." The latter moves to another desk and joins the others in getting his loose-leaf notebook and textbook out. He has forgotten to bring his calculator; this brings a firm and direct reminder later from the teacher to "remember your calculator tomorrow."

Mr. Smith opens a binder of loose leaf teaching notes and begins soon after the opening bell. "On Friday, we started to do some trig ratios," he says with a reminder of the concept introduction, and then quickly moves to the chalkboard to begin recording the formulas used last day. The students are evidently used to the quick pace. As he draws a triangle, he speaks out the parts he is drawing, "and the opposite side from the angle." Sometimes, a student volunteers the name he is looking for, for example "adjacent" or "hypotenuse." If the word is not said by a student, he says it himself as he draws, keeping the pace smooth and brisk. All students are following the board, checking their notes, or keying their calculators. At some points, Mr. Smith asks directly for information, as with "And the formula for cos is, please?" Several students may call out the answer. Rarely was there silence in answer to these general questions.

After ten minutes, the board has several formulas, three example triangles, and the prompt phrase "SOHCAHTOA." At this point, practice calculations are provided. "Let's do the Tan of 48," Mr. Smith says as he records the question on the board. "Find the decimal to three decimal places, please." He waits three or four seconds as he observes several students press the keys of their calculators. "And write it down," he continues. After a few seconds, he looks at one student and asks what he got. The answer is "One point one one." Another student suggests, "One point one one zero." The answer is recorded on the board. The task is repeated with the sin of 81. A third question is recorded on the board "Tan $x = 0.314$." With every question, now, Mr. Smith is allowing time for students to calculate, record and check. He moves about the room, making an observation at every student's desk for every question. He pauses longest at the desks of the students who missed Friday's class.

He announces "Back to number one; what does that 48 represent?" "Yes, the angle." This begins a review of terms, and leads into a review of how to properly key the calculator. He

notices some students having difficulty with the sequence of keying and uses this as a chance to review with everyone the two different kinds of calculators and their unique keystrokes.

A series of three practice questions, featuring a labeled triangle and the direction to "find x" are recorded on the board. Students are reminded to write down the question and they begin independent work. Mr. Smith moves to every desk, often reminding a student to record the question, or to "always write the ratio," or reviewing the quickest way to key in the calculator.

The answers to the problems are taken up with the class, and Mr. Smith becomes more direct in asking particular students to provide the answer. He commonly will stay with one student, asking him or her to call out their answers to three or four questions in a row.

A second series of three problems is put on the board. Other than a few reminders such as "write down the ratio, I always want to see the ratio," Mr. Smith focuses on individual students at their desks. By the time the bell rings, at forty minutes, to indicate the half point in today's double lesson, every student has been visited at least twice by the teacher.

The last series of practice questions from the board is taken up at the board with student answers and Mr. Smith recording them. With thirty minutes remaining in the class, he assigns three pages of about thirty questions each for independent work. Although students have had their texts out, and most have had them open, this is the first time they are used.

Mr. Smith reminds them that they have all of tomorrow's class as well to work through these questions. The room falls quiet and Mr. Smith takes advantage of the time to do some work at the computer in the corner and to take questions from students who come up to his desk.

Observation Day Two:

Mathematics class for Nine B on Tuesday is first period. They assemble at first bell, the majority sitting in different desks from what was observed yesterday. They have their math notes and texts, but no one has them open. Students listen to general announcements and then stand as a group for the singing of *O Canada.* Another bell sounds, and most students now move in an orderly and quiet way to the same seats they used for yesterday's math class. Within two minutes, the room is quiet and everyone is working through the questions assigned yesterday. A supply teacher arrives; Mr. Smith is absent to attend a field trip with grade eight students. Gradually, a few students move to be close to another student who is giving help with completing the work. After ten minutes of the class have passed, the supply teacher is busy moving to desks where students have questions, and there is a gentle hum in the room from four or five groups working through questions together.

Mr. Anderson, the principal, stops by to see how the class is doing, and mentions in a private aside that he never worries about Mr. Smith's classes being left to do independent work. This is mentioned in a more public way by an English teacher who stops by. He was asked by Mr. Smith to check on the class, but he tells the students that he never has to worry about them.

At the end of the forty minute period, three or four students mention that they have their questions done. Other students report that they typically have fifteen to thirty minutes of homework from mathematics class three or four nights a week.

Observation Day Three:

Wednesday's class is a single period in the afternoon. Mr. Smith has spent the lunch break in a tutorial with several of the students who were absent from classes on this topic. Three of the four students showed up; the fourth will get special attention in today's class.

Mr. Smith arrives at Nine B's room, again works from his loose leaf notes and announces that it is quiz day. From his loose leaf notes, he draws three triangles on the board, each with a labeled angle and side, and an '*x*' side to be solved. He remains seated at a front table and watches for everyone to finish. Students are asked to pass their notes forward one person for marking. The answers are taken up at the board, with students calling out answers. Mr. Smith is also keying every question in on his calculator. He instructs everyone to put the score correct as a percentage at the top of the page and return it to the owner.

The notes are passed back, he reads names from his mark book and records each score as it is called out. Most students call out "sixty-seven" or "one hundred," but one student reports "zero." He returns to that student to ask "Brad, any questions?" Brad practices a question on his calculator and determines that he was using the wrong sequence for his particular calculator.

A second set of three questions is put on the board. Then a third and fourth, with previous questions and answers wiped off each time. The sequence is repeated: independent work, passing papers either forward or back for marking, and recording of marks. Brad scores one hundred on the third quiz and gets a "Good" from his teacher. The fourth quiz is marked out of ten, with three marks divided amongst specific answers for each question and a bonus mark for having a name on the paper.

The class ends with a reminder from Mr. Smith that, because of interruptions in classes Thursday and Friday, homework is due on Monday.

Findings:

From observations made in three days of Nine B's mathematics classes, it is evident that several factors may explain their success. They include the following:

- accommodating a diverse but stable student group
- engaged learners
- direct and planned teaching

Each factor is discussed below.

Student Diversity

When asked to explain the success of Wayside School on grade nine achievement tests, Mr. Smith is quick to credit the students: "In the last three, four years, we've had some awesome classes." There are two grade nine classes, each of about twenty students. Mr. Smith teaches them both. Nine B, the class observed for this study is a generally able, but varied group. From information provided by parents, they can be described as coming from homes with a wide diversity of parent income and educational background, and rural or small town residency. Four or five students are amongst the most able, and quickly understand most concepts taught. There are, however, two students new to the school this year who don't seem to have had the same

preparation and who often require additional time and teacher assistance. Overall, Nine B is a little farther ahead in the schedule of topics for the year when compared to the other class, which has a few more students who need additional help.

How this group is accommodated can be viewed from the actions of A) Mr. Smith and of B) the 'team' of grade nine teachers and administrators.

A) Mr. Smith addresses the diversity of student needs in a variety of ways, including the following:

- direct teaching and guided practice of concepts
- involvement of all grade nines in a mathematics contest
- individual attention at every student's desk, every class
- tutorials or other out-of-class assistance

The three days observed are typical of the routine students experience for mathematics topics. Mr. Smith teaches from notes in his binder that include his year plan. The textbook is used as a source of examples for review and questions for practice. Quizzes and tests are frequent and teacher-developed. All students follow the same sequence of instruction, but, as the opening vignette to this study illustrates, time to attend to individual concerns or interests is allowed.

Mr. Smith credits his greatest strengths as being "consistency and fairness." Just as every student knows of the requirement to have a calculator, notebook, and text ready for every class, so are they aware that if they miss a class for any reason, they will be expected to catch it up through a tutorial or a call home.

B) The school administrators and all grade nine core subject teachers, including Mr. Smith, provide the following:

- continuity across grades and subjects
- instruction in test-wiseness
- high expectations for all students
- access to teacher at home by telephone

The population at Wayside School, which covers grades 4 through 12, is relatively stable. Although Mr. Smith has taught grade eight before, this is the first year he has taught these particular students. However, he and the students are both aware that he will be their mathematics teacher next year, whether they choose the applied or pure course of study in grade ten. This continuity of instruction has caused him to view this year as a base year for many mathematics learning goals. He is anxious to have these students prepared for an ambitious course next year.

All grade nine teachers act as a team in setting and supporting expectations for student behaviour and performance. Several students identified in a written survey that they found their teacher easy to reach for questions, even at home. When asked about this, Mr. Smith explained that the teachers don't merely offer their home numbers, they expect students to call. As part of their goal for students to come to class prepared, the teachers want them to communicate

problems before class. If the class moves on to a new topic before a student is confident with the material, he or she will suffer. The responsibility of the student is to communicate to Mr. Smith before class, whether it be a calculator problem, a missing homework assignment, or confusion about a particular topic.

Several of the students missed the introduction to the concepts last class due to a field trip. He is interested, but confident, in how they will pick up the work today, but confident they will be able to do so. As was mentioned earlier, these students are new to him, although he has taught grade eight mathematics in the school before. He will see all of these students next year in either of the two math courses they select in grade ten. Knowing what they will need for those courses, and wishing to have them ready to take responsibility for their learning and organization, he keeps up a constant commentary on the need to watch examples, have materials at the ready, and to practice. But questions and alternate ideas are acceptable. The question raised in class today may only have represented one student's depth of thought about the processes, but was treated as a legitimate cause to spend some class time.

Engagement

Class Nine B is an orderly and attentive group of students. They stand as a group for the singing of the national anthem in their classroom, they move efficiently into a unique seating plan for mathematics class, they attend to teacher presentation and questions, and they work quietly, with or without direct supervision, on independent assignments. They report that they value mathematics as a subject and are aware of the importance of the achievement tests that they will be writing. However, their engagement in the mathematics they are learning may be more easily explained by their personal regard for Mr. Smith.

As a group, the students don't feel that they are very good at mathematics, yet they remain confident they will do well on the provincial mathematics tests. They give the credit for that confidence to their teacher. A typical response is that he "gives us help on the board thoroughly and, if we have questions, helps us." Remarkably, Mr. Smith takes on a heavy load of extra- and co-curricular involvement in student sports activities. Mr. Anderson has calculated that just Mr. Smith's coaching of volleyball alone in the fall would have filled forty-one full days teaching time. Students may see him as committed to them personally and reward this commitment with their full attention in class.

Parents of eleven of the twenty students responded in a written survey that they have high expectations for their children. Homework and tests are valued and practiced at home, even though parents freely admit they don't feel confident in helping with the mathematical content of the work.

Mr. Anderson is specific in describing Mr. Smith's success: "He is consistent, has classroom control, he is focused, and he has a traditional approach." When pressed, he explains that some group work occurs, and many manipulative materials, such as alge-tiles, are used where appropriate, but the accountability for learning is individual and communicated clearly to the students. Teaching is direct.

Deliberate and Planned Teaching

Mr. Smith has been teaching mathematics for six of his ten years. He is a Phys. Ed. major, Mathematics minor, and teaches the 9, 10, 13, and 23 mathematics courses. He has also taught the 7, 8, and 33 courses. He is knowledgeable about the curriculum and stays current through professional development activities in his district and by attending conferences.

He teaches from his own written plans and notes. The yearly plan is presented to his principal in the fall and is available for review throughout the year. He likes the textbook, but finds that he likes his own way of introducing many concepts. For the most part, the textbook is a source of questions for review and practice.

Mr. Smith makes frequent and fast-paced use of the chalkboard for presenting models, drawings, and formulas. He calls on students frequently for answers to questions posed at the board and makes many reminders about rules that must be followed or procedures that are to become routine. When not presenting or questioning at the front of the room, Mr. Smith moves about the room pausing at students' desks and providing suggestions or reminders. As described in the opening vignette to this study, he keeps a steady pace that is rarely interrupted. He is never harsh in his comments to students, but frequently uses direct, firm directions such as "remember to write this down," and "this is the way I want to see it on the tests." Mr. Smith presents himself as a concerned but friendly and supportive teacher. His talent as a coach informs his attitude towards teaching mathematics, as does his role as a high school mathematics teacher. He sees himself as building a group of learners with the basic skills they will need in both the near and more distant future. The achievement test is valued: it is referred to in class work and forms thirty percent of the students' final class mark in their subjects

Mr. Smith feels that he assigns a lot of homework, a view shared by students and parents. Students report spending from twenty minutes to half-an-hour three or four times a week on homework.

Advice

Mr. Anderson, Principal of Wayside School, is quick to give full credit to Mr. Smith. He is a principal who "likes to brag about my students, my teachers." It is clear, however, in talking to Mr. Anderson that he also has an impact on what is an overall school performance in meeting provincial standards. He knows that expectations at his school are high; he hears this from students (and their parents) who transfer in from other schools. He values the testing program and is proud of the high participation rate of his students.

The teaching and learning of mathematics at Wayside School is goal-directed, purposeful, and orderly. The last word goes to Principal Anderson:

"Advice I would give to another school: Rely on traditional skill development, provide extrinsic demands, remain positive, exercise control, employ a qualified teacher, and give teachers tools and freedom."

Appendix A:
Toward an Understanding of Teaching Practices Related to Student Achievement

Elaine Simmt

Elizabeth Mowat

Communication, problem solving, building student understanding, engaging students in instruction and organization

These were the characteristics of good teaching identified by a group of teachers in a study by Sullivan and Mousely (1994). These qualities are very similar to the characteristics of good teaching identified in a variety of research studies of mathematics education.

The purpose of this paper is to provide an overview of research in mathematics education that has focused on teaching practices and teacher characteristics that are related to student achievement in mathematics. This literature review is only one component of a research project in which we intend to study and learn about the teaching practices in schools whose students perform well on the Province of Alberta's Grade 9 Mathematics Achievement Exam. Case study research conducted on site in 9th grade mathematics classes and observations and reflections of a working group made up of teachers, teacher educators and educational researchers discussing the needs and possibilities for teacher inservice are the other components of this project. The final outcome will be a set of principles to guide the development of in-service education in Alberta (Figure 1).

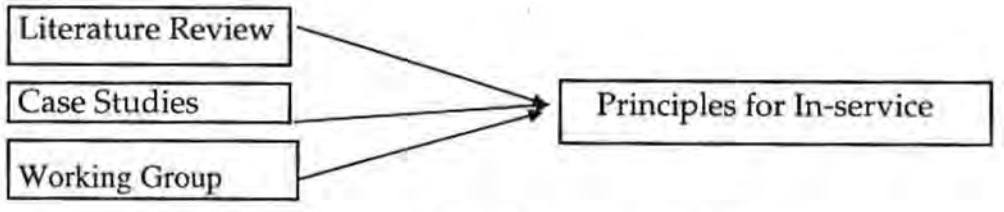

Figure 1 Overview of Project

To locate research focused on teaching and instructional variables related to student achievement we used the "Web" to search ERIC and the University of Alberta's library system through the GATE. Our search terms included: mathematics achievement and teaching; mathematics achievement and instruction; teacher variables and mathematics achievement; teacher characteristics and mathematics achievement; effective teaching and mathematics achievement; effective schools and mathematics achievement; and exemplary schools and mathematics achievement. In cases such as mathematics achievement and teaching, where thousands of hits were made, we restricted the search to secondary school education and journal articles. A few monographs such as *Effective Mathematics Teaching*, *In Search of More Effective Mathematics Education* and volume 25 issue 6 of the *Journal for Research in Mathematics Education* were central to locating further research studies. The search was not exhaustive. Rather, there was an attempt to represent a variety of studies.

Many of the studies we found discussed not just one but a variety of variables that might be related to student achievement. After reviewing the articles we grouped variables into the following categories: instructional practices, teacher characteristics, school climate and school leadership, student variables, and prior achievement. Because many of the studies considered variables from different categories and because we believe that teaching should be studied as a practice in a context, we will discuss all of our categories of variables even though the study is focused on instructional practices. Our discussion will be presented in order of relevance to the purpose of our study.

Instructional Practices

Recent research based on constructivist (Fennema, Carpenter, Franke, Levi, Jacobs, Empson, 1996; Steffe and Kieren, 1994) and socioconstructivist (Yackel, Cobb, Wood, 1991) theories of cognition paint a complex picture of the nature of teaching and learning. At the heart of these studies is a commitment to teaching with meaning and for understanding. Although this research has focused on young children, it is particularly valuable for informing our understanding of teaching given our current situation in Alberta schools—implementing a curriculum based on constructivist principles. Two research projects, in particular, are very impressive. In my view they are exemplars of research about teaching and learning. Not only have these two projects been ongoing for a number of years (since the mid 1980s), but the researchers have been very prolific, publishing many studies relating various dimensions of their respective projects. These projects teach us that studying teaching (and learning) in context and in all of its complexity is possible and valuable.

We will organize this section in the following way. First we will discuss some of the findings of the two major teaching projects noted above. Then we will review some of the literature designed to identify and measure instructional and teaching variables related to student achievement (generally understood as performance on standardized, paper-and-pencil tests).

Cognitively Guided Instruction

This research program (Fennema et al., 1996) is focused on building on teachers' knowledge by helping them understand the development of children's mathematical thinking and then using this knowledge to inform their instructional choices. In particular, teachers in the project grew to understand how their students' thinking could form the basis for the development of more advanced mathematical ideas (p. 406). The project consisted of teacher development workshops and ongoing support for teachers in their classrooms. The researchers observed the teaching practices for over 4 years and monitored student growth in mathematics understanding. What is striking about this program is that the teachers were not told how to teach or what they should do in their classrooms. Rather they were given plenty of opportunity to learn about children's thinking through the viewing of video tapes of children problem solving, and through discussions about how the children thought and problem solved (p. 407). Teachers were instructed to ask their children to solve problems, ask the children how they solved the problems, and then think about the children's solution strategies (p. 408).

Many facets of the study have been reported. Some of their reported findings include (reviewed in Fennema et al., 1996):

- Experimental teachers spent more time than control teachers having children solve problems, were more likely to expect multiple solutions strategies from children, and

listened to children more than control teachers (Carpenter, Fennema, Peterson, and Chiang and Loef, 1989)

- Positive relationships were found between students' learning and their teacher's beliefs and knowledge about their own student's thinking (Carpenter, Fennema, Peterson and Carey, 1988; Peterson, Fennema, Carpenter and Loef, 1989)

And, using the longitudinal data from 4 years of the study, they found (Wood and Sellers, 1996, pp. 429–430):

- "90% of the teachers had become more cognitively guided"
- their instruction "epitomized" the process standards of the National Council of Teachers of Mathematics (NCTM) reform movement
- "the students spent most of their time engaged in true problem solving"
- "seventeen of 21 teachers came to believe more strongly that children could solve problems without being shown procedures for solving them, and that solving many carefully selected problems enabled children to learn mathematics"
- the teachers came to believe that their role was not to tell children how to think, but to provide an environment in which children's knowledge could grow as the children engaged in problem solving activity
- the teachers perceived their role to lead children to more mature problem solving by providing appropriate problems and by asking questions of the children as they discussed problem solutions
- the children's gains in problem-solving and achievement appeared to be directly related to the changes in the teachers' instruction—although the researchers could not identify specific instructional changes because the teachers' instruction changed along several dimensions
- although the instruction emphasized problem solving, the students did not experience a decline in computational skills.

Although the Cognitively Guided Instruction Research Program involved grades 1 – 3, this study is one possibility for teacher education that focuses on teacher growth not just in a single dimension but along many of the dimensions that come into play when teaching.

The Purdue Problem-Centered Mathematics Project

Paul Cobb, Erna Yackel, Terry Wood (1991, 1996) and colleagues developed a teacher education program reflecting the principles of socioconstructivist theory of knowing and compatible with the NCTM's vision of reform for mathematics education. This project grew out of a year long research project in which a set of instructional materials were developed with a second-grade teacher. In the second year of the project, 18 additional teachers were added to the study; four years later materials were developed for a third grade class. The program continues to be in effect in the schools district in which it was developed.

The characteristics of a problem-centered classroom (in this project) includes classes of no more than 22 students, 20 – 25 minutes of the children working together in pairs followed by

15 – 20 minutes of whole-class discussion. There is also the possibility that the teacher may lead an activity, where appropriate, or that the children spend the whole class working in pairs. The instructional activities were developed based on an understanding of children evolving conceptions of numeration and of nonstandard algorithms for addition/subtraction and multiplication/division. The problem-centered activities were created to be interpretable to students in a wide variety of ways.

A number of research reports have come out of this project. For example, Yackel, Cobb, and Wood (1991) explore how small group interactions become a source of learning opportunities in these classes; in another paper Yackel and Cobb (1996) discuss sociomathematical norms, argumentation and autonomy in mathematics; and Wood and Sellers (1996) discuss student performance given participation in the project. They found that project classes score significantly better than non-project classes and project classes with a textbook on computational items on the state-mandated multiple-choice standardized achievement test (ISTEP), which is composed of a computational subtest and a concepts and applications subtest. The project class also performed significantly better on the total test. Classes in the study also wrote a test designed by the researchers. This test has two scales, an instrumental scale and a relational scale (Skemp, 1976). On this test there was no significant difference between the project group and the non-project group on the instrumental subtest (traditional computational tasks), but there was a significant difference on all but two of the relational items (a multiplication picture item and an item involving money). An instrument was also used to test the students' personal goals and beliefs. The only significant difference between the groups was the belief exhibited by the project group that success in mathematics is related to finding their own and different ways of solving problems rather than conforming to the methods shown by the teacher.

Studies about Teaching (Instructional)[1] Variables

We chose to begin this review by discussing two research programs, the Cognitively Guided Instruction program and the Purdue Problem-Centered Mathematics Program. Both of these programs use instructional methods and content that is aligned with the reform efforts of the NCTM (and similar to the curriculum change in Alberta). In both of the projects students usually performed better than comparison groups and never worse. This discussion was put up front in this section to make the point that teaching toward the reforms recommended by the National Council of Teachers of Mathematics is not only possible but has the potential to improve student performance in mathematics.

We will now turn to a review of a variety of other studies that have attempted to better understand effective teaching by looking for relationships between instruction and student achievement. The list is not exhaustive. It is based on a selection of research studies that were conducted over the past three decades. Further, most of the studies selected for this review measured teacher effectiveness on the basis of student achievement gain, as measured by standardized test scores.

[1] These words are used differently by various researchers. I am using, teaching and instruction interchangeably here. I am using these words to refer to the teachers actions to teach a concept or process, or establish a learning environment.

There have been a number of reviews of the research on teaching: Cooney in 1980 and again in 1994 and Begle in 1979 were the main review sources used in this study. For those interested in further exploring this topic *The Handbook of Research on Teaching* (Wittrock, 1986) is also a source for a reviewing this literature.

Cooney (1980, 1994) suggests that we observe teacher behavior from three perspectives: the affective, the cognitive, and the managerial. For each of these three perspectives he distinguishes two levels of inference that can be made based on behavior, high and low (Table 1 adapted from Cooney, 1980). He notes that conviviality, enthusiasm, clarity, variability, business-like behavior and directness are teacher behaviors found to be correlated with student achievement.

TABLE 1 - Classification of teaching variables with examples and descriptors

DOMAIN	VARIABLES	
	High Inference	Low Inference
affective (emotional, anxiety, attitudes)	conviviality, enthusiasm	praise
cognitive (manipulation of content, math correctness, variability of explanations, use of heuristics in problem solving.)	clarity, variability	use of examples, nonexamples
managerial (withitness, promotion of student on task behavior)	businesslike, directness	wait time

We will use Cooney's classification system to discuss the findings from my review. The placement of the attributes and behaviors is ours. In many cases (as is often the case in the study of human behaviour and characteristics) the categories overlap and are not clearly defined. It may be helpful to think about them as having "fuzzy boundaries."[2]

Affective behaviors

A number of studies have found teacher enthusiasm and teacher warmth to be related to student achievement (cf. Cooney, 1980; see also review by Begle, 1979); whereas, negative correlations were observed for teacher abruptness, belittling, defiance, sarcasm and shaming. Although these findings were reported in the research, Cooney cautioned us about the nature of these affective variables. There is "some question," he writes, "as to how contextual affective variables might be." For example, Cooney cited the work of Brophy and Everston (1976). They found higher correlations when lots of praise was used in classes with students of low socioeconmic status (SES) whereas, lower correlations were noted for classes with students of

[2] Fuzzy logic expands the possibilities for a system because it allows for multiple classifications of a single concept or idea.

high SES. That is, with low SES classes there are positive correlations for teacher warmth and encouragement; whereas with classes of high SES the correlations are high when the teacher is demanding. The concept of demanding is interesting. Many studies have noted that a demanding teacher's students have greater gains in achievement than a teacher who is not demanding. Recent studies, both quantitative and qualitative seem to support the positive relationship between demanding instruction in a supportive environment and student achievement (Driscoll, 1987; Westbury, 1994; Wood and Sellers, 1996;). "Demanding" is one of those variables that exists within a fuzzy boundary. When a teacher is demanding sometimes this refers to high expectations for the students with respect to working hard and performing well (Driscoll, 1987) or promoting self-sufficiency (Cooney, 1980). This characteristic seems to fit into the affective domain.

The Cognitive

At other times 'to be demanding' may mean focusing on the difficult concepts in mathematics (Westbury, 1989; TIMSS, 1997), teaching concepts through problem solving (Fennema, et al. 1996); teaching with meaning (Sigurdson and Olson, 1992); ensuring students actively participate in the lesson (Good and Biddle, 1988; Tobin, 1989; Westbury, 1989, Yackel, et al., 1992); encouraging rigor (Reynolds and Walberg, 1992) or demanding explanations (Yackel et al., 1992. Fennema et al. 1996) Each of these behaviors fits with what Westbury has called a cognitively demanding approach to mathematics instruction.

Studies from almost 3 decades ago found support for the relationship between teacher clarity with student achievement (Rosenshine and Furst, 1971; Barr, 1969). More recent studies corroborate this finding (Porter, 1991; Begle, 1979; Good, Grouws and Ebmeier, 1983). Clear explanations (Westbury, 1989) and conceptually oriented explanations (Fuchs et al., 1987) have also been found to correlate positively with student achievement. In contrast, teacher vagueness was found to be negatively correlated with student achievement.

Another set of variables that seem to be strongly correlated with student achievement have to do with content coverage, inclusion and emphasis (Hembree, 1992; Reynolds and Walberg, 1992; Sosniak and Ethington, 1989; Begle, 1979; Cooney, 1980). This is not a surprising finding. It makes sense that students who cover a topic in class or for whom a topic is emphasized will do better on a test of the content than students who do not learn the content in class. There have also been correlations noted for amount of time allotted to mathematics instruction (Westbury, 1989) and the amount of time used to teach the content within a class period (Good, Grouws, and Ebmeier, 1983).

Managerial

Teachers who are organized, business-like (Begle, 1979), task-orientated, set goals and use class time effectively (Driscoll, 1987) were also found to have students with greater achievement gains (cf. Cooney, 1980;1994). Teachers who communicate to their students that they know what is going on regarding student behavior also are effective. This is another of the variable sets that does not get consistent correlations. For example, the task-oriented teacher may not be as likely to teach for higher order outcomes (cf. Cooney, 1980;1994).

"Trite as it is, the saying 'teaching is an immensely complex phenomenon' needs to be repeated here. This complexity makes it very difficult to conduct, review and synthesize

research on teaching particularly with respect to specific variables." (pp. 455–456)..."Part of the complexity of teaching can be attributed to the settings in which the teaching occurs." (p. 456)

Teacher Characteristics

Cooney's 1980 review begins by noting three extensive reviews of research on teachers' characteristics. The first is one by Fey (1969) that reports that no definite relationships have been found linking teachers' characteristics, such as experience, college courses, grades in courses, or participation in professional activities, and student achievement. More recent research, using the grade 8 SIGs data, again found that relationships between years of experience teaching (Westbury, 1994) or teacher education (Sosniak and Ethington, 1989) and student achievement is are significant. However, there is some evidence that teachers' knowledge and ability is correlated with student achievement (Mullens, John et al. 1996). Further, in a case study of exemplary programs, Tobin (1989) notes that teachers were very knowledgeable of the content and when they were not it showed. Finally, there is also some evidence from expert/novice studies that expert teachers are more knowledgeable about the content (McKinney, 1996; Leinhardt, 1988).

School Climate and Leadership Characteristics

As one pulls back and moves further from the classroom, one's understanding of what matters in mathematics education is enhanced by a picture of the school community and the school leadership. In particular the number of studies in the area of effective schools and exemplary programs is growing. We are also informed of these kinds of variables by some of the large-scale testing conducted in recent years.

In the IEA Study of Mathematics II, Schmidt and Kifer (1989) note that "the types of variables at this level that are related to differences in achievement are neither easily identified nor easily measured" (p. 226). This particular study found paradoxical results: things like the larger the class size the greater the achievement, the more help a student receives the lower the student's achievement, and the greater portion of mathematics specialists teaching the poorer the students' achievement. The authors note that some of these findings must be explained more deeply to better understand why they are contrary to expected results. In particular, they note that there is not information to say why these results were obtained.

Given that this is an extraneous portion of the review, the search for related literature was not as extensive as it was for teacher variables. However, the search we did conduct suggests for us that academic press or academic rigor is certainly one of the characteristics of school communities and programs that have effective and/or exemplary mathematics programs and whose students are achieving in mathematics.

A study of exemplary mathematics programs in the United States conducted by Mark Driscoll (1987) noted that the leadership in these schools results in well-run and well-organized departments that free teachers from non-instructional distractions. Further, the leadership makes it possible for teachers to feel and act as professionals. Tobin (1993) in a study of exemplary mathematics and science programs in Australia noted similar characteristics and also commented on how the teachers did not seemed burdened with the onerous task of dealing with classroom management problems. Notably these programs screen applicants and the students who attend

these schools make for very unique classes. Although these findings are not the sort that one would generalize from, they are findings that demonstrate the importance of climate and community support for special programs that strive for academic excellence.

In other studies of schools not necessarily noted for exemplary programs, consistency and coherence of educational goals (see Begle, 1979) and in curricular orientation (see review in Sosniak, Ethington, Varelas, 1994) are related to mathematics achievement. In a Ph.D. study, comparing communitarian school climate with a climate of academic press, Phillips (1997) noted that only the academic climate—one which she referred to as having academic press—was positively related to mathematics achievement. Unfortunately her study is limited in that academic press was strongly related to school composition. Thus there may be other subtle factors related to mathematics achievement that were not noted. In this paper Phillips notes that Shouse (1996) found academic press is related to student achievement in low SES schools; however, Philips' study did not support this finding.

Sammons et al (1993) in their study of inner-city schools in London found that "although in general terms schools which are effective in promoting progress in mathematics are successful for pupils of low and high initial attainments, and those which are ineffective tend to be ineffective for all pupils, some schools are more effective for pupils with low attainments than for those with high initial attainments and vice versa" (p. 392).

There is some discrepancy in the research with respect to whether other school characteristics such as size of school, size of class, and number of minutes of mathematics instruction are associated with student achievement in mathematics. Studies conducted in the 1960s and 1970s did not find many school variables associated with student achievement (see for example Begle, 1979; Barr, 1969; Coleman et al. 1966). Critiqued on the basis of inappropriate modeling techniques these studies have been called into question recently by researchers suggesting that Hierarchical Modeling Techniques are required for such variables (Murchan and Sloane, 1994). The studies which use these techniques are indeed changing what we know about the effects of schools and teaching.

Student Characteristics

Student characteristics are commonly considered in studies that attempt to find correlates with student achievement. Even when they are not the direct focus of the study they are uncovered. We will consider three groups of characteristics: cognitive, affective, and contextual. The cognitive generally refers to mathematical knowing which is often defined by researchers on the basis of some test of the students' computational and/or problem solving abilities. The affective most commonly refers to beliefs and attitudes towards mathematics, motivation, and self-knowing. In addition, we will include a group of characteristics that we refer to as contextual which refer to the context or situation in which the child lives. This would include family and community variables. In particular we are thinking about gender, ethnicity and family socioeconomic status.

Many studies are focused on achievement in a particular domain, such as problem solving (see meta-analysis by Hembree, 1992) yet these same studies measure achievement by means of a paper-and-pencil test. Begle (1979) notes that computational skill (which happens to be easier to measure with a paper-and-pencil instrument) is often used to determine mathematics

achievement but the variables associated with student achievement at the computational level may not be the same as those associated with achievement for higher order cognitive skills like problem solving. For many of the studies we reviewed there was no distinction reported in terms of computational skills or problem-solving skills. Most studies reviewed for this paper which identified student characteristics related to student achievement were based on some form of paper-and-pencil test (in part because of the difficulty of doing otherwise and in part because paper-and-pencil instruments, although they narrowly define achievement, can be demonstrated to be reliable). Another group of studies we came across in our review were those studies that focused on trying to understand (often the effectiveness) of a particular instructional strategy or resource. The results then from the literature search include all three kinds of studies.

The most pervasive finding from all of these studies is prior mathematics achievement[3] (scores, grades, ability) is positively and significantly correlated with current student achievement (Hembree, 1992: William and Schmidt, 1989; Sammons, Nuttall, Cutangce, 1993; Marsh, 1996; Ethington, 1992). Other findings include: gender —favoring males under some conditions and favoring females under other conditions (William and Schmidt, 1989) and recent studies suggesting no significant difference, (Tate, 1997); socio-economic status[4] (SES) (Rogers, 1997); and race-ethnicity (Tate, 1997). Race-ethnicity has been correlated with student achievement (Tate, 1997) with African Americans and Hispanics doing poorer than White students and students of Asian descent. However, Tate notes that African American and Hispanic students made greater gains between the years 1973 and 1992 than did White students. This finding is tempered by the fact that the gains have been made in basic skills only. This finding is supported by Hembree's (1992) meta-analysis which found a negative correlation for these same groups with respect to achievement in problem solving.

Studies of the affective domain also inform our understanding of the student variables that are associated with student performance in mathematics. They include student attitudes towards mathematics, beliefs about mathematics, and emotional reactions to the subject (Mcleod, 1994). In a meta-analysis, Ma and Kishor (1997) noted there was a "significant but not strong" (p. 39) effect between attitude towards mathematics and achievement in mathematics.

Summary

In this paper we reviewed a number of studies that focused on teaching and mathematics achievement. From the studies, we learned that student characteristics, some teacher characteristics and practices, and to a lesser extent school characteristics were found to be correlated with student achievement in mathematics. With respect to teaching practices in mathematics we have found that content covered, cognitively demanding instruction, teacher

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[3] A Note Concerning Prior Achievement
Study after study points to the importance of taking into account students' prior achievement regardless of what one is studying (Sammons, Nutall, Cuttance, 1993: Williams, Schmidt, 1989; Reynolds, and Walberg, 1992; Begle, 1979; Wunert, 1995). Student prior achievement is the most frequently noted finding in the studies that were reviewed for this paper. In studies that used multilevel modeling techniques, correlations were not as easily found for student characteristics like SES, gender, and race-ethnicity. This is an important observation if one is attempting to understand teaching practices that may be correlated with gains in student achievement.

[4] In a recent study by Rogers (1997) SES was found to account for up to half of the variance among schools on achievement tests.

clarity, and a business-like attitude were positively correlated to student achievement. More strongly correlated to student achievement were student characteristics and in particular prior achievement in mathematics. The literature search uncovered some studies of exemplary schools in mathematics. These schools demonstrated program consistency and coherence and they stressed academic rigor. These findings cannot be generalized given the elite nature of the programs.

Given these studies and the findings reported by the researchers we must not lose sight that we expect our students to learn more in our math classes than we can assess on paper-and-pencil tests. Brophy (1987) cautions us.

> *Teacher effectiveness in eliciting student achievement gain cannot be equated with teacher quality, because teacher quality is a broader concept that usually would be defined to include not only achievement outcomes but affective outcomes such as stimulating student motivation to learn the subject matter and developing students' sense of efficacy and confidence in learning (p. 14).*

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Appendix B
Principles for Inservice Education

Elaine Simmt

The nature and quality of learning experiences for teachers are a concern for teacher educators as they search for ways that will help teachers grow in their knowledge of teaching mathematics and help them adapt their teaching practices in light of new curricula. Teachers' teaching practices are affected by who they are, what they believe, what they know, and how they know (Thompson, 1984; Shulman, 1986; Fennema and Franke, 1992). Their practices are also affected by the children they teach, the mathematics they engage in with their students, and the colleagues with whom they interact. Teaching is a complex phenomenon—a phenomenon that is enacted in the classroom and one that coemerges with student learning (Kieren, Simmt, Mgombelo, 1997). Changes in teaching practice do not come about by teachers simply taking one set of practices and replacing them with another; rather, teaching practices are transformed as teachers try out new ideas, learn new mathematics, meet new children, and confront curriculum changes (Shifter, 1997).

As part of the teaching practices study, some of the mathematics teachers whom we observed, and the mathematics education researchers who observed these teachers met as a working group and discussed principles for inservice education for mathematics teachers. In these discussions, we considered the distinction between professional development and teacher inservice and we began to develop a set of principles for inservice education for mathematics teachers. This appendix is a report of the discussions of the working group.

Professional development and teacher inservice: making a distinction

The terms professional development and teacher inservice appear to be used in a variety of ways by members of the teaching profession and teacher educators.[1] In the working group, the teachers and researchers discussed these distinctions. The term professional development appeared to be used more broadly than the term inservice. For the members of the working group, professional development activities were thought to be related to the general interests of teachers and implied a long term vision for both one's professional and personal life. Thus, professional development activities were not necessarily related to teaching mathematics, instead professional development might involve more general topics like time management, strategies for planning, using computers, learning theories, and so on. Further, there was acknowledgment that professional development is not restricted to taking courses or attending conferences, it also includes reading the professional literature, ongoing and active participation in professional organizations, participation in action research and collaborating with colleagues.

Inservice education, as the working group conceptualized it, was thought of as a subset of professional development. Whereas professional development is used to speak of teachers' ongoing learning in general, inservice is thought to be more specifically focused on a teaching area and often involves particular teaching strategies or specific content. Further, inservice opportunities tend to be in response to the immediate needs of teachers and focus quite directly on teaching practices and issues related to the classroom. Because inservice education is for

[1] There are also distinctions made between undergraduate students in education (preservice teachers) and teachers already in the profession (inservice teachers).

practicing teachers, there is a sense that such opportunities should be practical—in the sense that they inform one's teaching practice. The members of the working group choose to narrow our discussions by focusing only on inservice education.

Teacher inservice: an opportunity for growth

When the working group members were asked, as a mathematics teacher what conditions foster your ongoing growth, they offered a number of suggestions. The teachers noted that they believed it is important to begin one's career from a strong position; that is, teachers need to know mathematics and know what it is that their students are expected to know. In addition to "knowing" these things, members of the working group also suggested that teachers must be enthusiastic about mathematics and have a understanding and appreciation for children and youth. From their point of view, if these conditions are in place then there likely will be a desire to continue to learn in order to improve one's teaching.

The challenge for teachers, then, becomes one of selecting high quality inservice opportunities to keep abreast of innovations in one's teaching area, to share work with other teachers, and to work on one's own teaching strengths and weaknesses. Teachers in the working group suggested that when selecting inservice opportunities they ask: What is the purpose of the inservice?; and, In what way is this inservice important to me as a mathematics teacher?. From this perspective, all inservice should be useable and have long term benefits for both teachers and their students. Three dimensions of inservice were identified by the group as important considerations for all inservice sessions: the content, the experience, and the facilitator.

The Content:

The teachers in the working group agreed the content of inservice opportunities must be specific and address teacher needs. It might include introducing new programs and/or new content within existing programs; it might focus on new mathematics and/or mathematics new to the curriculum; it might offer opportunities for teachers to work on new teaching strategies, share ideas for adapting existing teaching practices, or teach teachers how to use manipulatives for teaching and learning mathematics. This conception of teacher inservice includes short term activities related to specific teaching areas, instructional sessions on how to do something and sessions in which information is passed on to teachers. These are not all of the possibilities for teacher inservice however, they are a few that the teachers in our working group thought were significant at this time given the circumstances of new mathematics programs in Alberta schools.

The Experience

Inservice sessions should be challenging, fun, informative and extend the teachers knowledge with respect to their own instructional practices. The experience should be practical and hands-on. It should model the kinds of teaching that it is promoting and, where possible, classrooms should be simulated. The working group members felt that it is extremely valuable to put the teacher into the position of learner—mathematics learner in particular. Further, teachers should not simply be presented with opportunities to do mathematics with which they are very familiar, but teachers should instead learn new mathematics.

Another feature of good inservice, from the perspective of members of the working group, is that it establishes opportunities for teachers to network, learn from each other and develop ongoing conversations. Inservice experiences should provide teachers with an

opportunity to share personal experiences (stories) and validate teaching practices. In this way the inservice sessions give teachers the opportunity to reflect on their own practices and the suggestions that are new to them.

The Facilitator

The third component of teacher inservice is the facilitator or presenter. Just as a good teacher makes a difference in a classroom, so too does a good workshop or session facilitator. It is important that those people who lead sessions should come to the sessions with a variety of experiences from which they can speak and share. They must be role models with respect to teaching and learning and must be able and willing to engage teachers as learners and to learn with teachers. The teachers in our working group emphasized how much they learn when they learn with other learners, be them students, colleagues or teacher educators.

Creating opportunities for learning

Teacher inservice is about providing opportunities for professional learning. The need for particular inservice sessions depends on the context in which teachers are teaching. As new curricula is introduced, or research about teaching and learning becomes known, as new mathematics is created and new tools for doing mathematics become available, teachers need opportunities to learn and to adapt their teaching to include that which is new. Teacher inservice is one of many possible ways in which teachers can grow in their professional knowledge.

The teachers in this study are life long learners. They learn from their students, from colleagues and from teacher educators. Their practices evolved not only from participating in inservice opportunities, but also from ongoing dialogue with colleagues, reading professional material and from working with their students. Their advice to us as teacher educators is valuable; their example as good teachers is even more precious. We believe that the case studies documented in this report provide yet another opportunity for teachers to reflect on their teaching practices.

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Appendix C:
Selecting Exemplary Schools in Grade 9 Mathematics Using Alberta Education Achievement Test Results

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University of Alberta

To identify schools in the province of Alberta that have strong student performance on the Alberta Education Grade 9 Mathematics Achievement Tests there is a need to operationalize the concept "strong student performance." Furthermore, there is a need to select schools representing the diversity of students in the province. Variables such as location (i.e., rural vs. urban), geographic area, and class size were considered. We also wanted to identify at least 20 different schools for study. With these variables in mind, the criteria used to select the target schools are described below.

A. Selection Criteria for Large Schools (n>=25)

- Number of Students Writing the Alberta Education Mathematics 9 Achievement Test: Must meet or exceed 25 students in a given year
- Student Performance at the Acceptable Standard on the Alberta Education Mathematics 9 Achievement Test: Must meet (=) or exceed (+) provincial expectations in a given year (the flags = and + are based on statistical outcomes used by Alberta Education)
- Student Performance at the Standard of Excellence on the Alberta Education Mathematics 9 Achievement Test: Must exceed (+) provincial expectations in a given year
- Participation on the Alberta Education Mathematics 9 Achievement Test: Must meet or exceed 95% in a given year (i.e., percent absent is 5% or less in a given school)
- Trends in School Performance: The criteria outlined above must be met for two of the three year examined (i.e., two of 1995, 1996, and 1997)

Twenty-four schools in the Province of Alberta met these criteria. Twenty-one of the 24 schools are in the province's two largest cities.

B. Selection Criteria for Small Schools (5<=n<=24)

Since the selection criteria for large schools was over-representative of the two major cities in Alberta, selection criteria for small school were also created. The small schools criteria include:

- Number of Students Writing the Alberta Education Mathematics 9 Achievement Test: The number of students writing must be between 5 and 24 students in a given year
- Percentage of Students Performing at the Acceptable Standard on the Alberta Education Mathematics 9 Achievement Test: Must meet or exceed 85% in a given year (the criterion of 85% is not based on a statistical test)

- Percentage of Students Performing at the Standard of on the Alberta Education Mathematics 9 Achievement Test: Must exceed 15% in the given year (the criterion of 15% is not based on a statistical test)
- Participation on the Alberta Education Mathematics 9 Achievement Test: Must meet or exceed 95% in a given year (i.e., percent absent is 5% or less in a given school)
- Trends in School Performance: The criteria outlined above must be met for two of the three year examined (i.e., two of 1995, 1996, and 1997).

Appendix D:
Interview Protocol—Teacher

- When I observed your class, I noticed _____. Could you comment on that?
- What is your greatest asset with respect to teaching? In what way is this your greatest asset?
- In your view, what are the reasons your children do well on achievement exams?
- In your view, what is it about your teaching practices that are related to students doing well on achievement tests?
- In what way do the achievement exams reflect what your children know?
- What do they not reflect about your students' mathematics knowing?
- In your view, what, if any, are some of the school policies and/or procedures that support mathematics teaching and learning?
- In your view, what are some of the district based policies that support mathematics teaching and learning?
- Has your school specifically focused on mathematics achievement and if so in what way(s)?

Consent Form

Teacher _____

School _____

Are you interested in participating in our research project? _____

Will you allow a researcher to observe in your mathematics class? _____

Do you have any concerns about having a researcher observe you teaching your class?
Please use back of sheet to elaborate.

Will you allow a researcher to interview you about your teaching practices? _____

Do you have any concerns about being interviewed by a researcher for this project?_____

Please use back of sheet to elaborate.

Signature

If you are agreeable with participating in this research will you please complete the following information. It will be used to describe the teachers we observed. We will protect your anonymity by not identifying you, your principal, your school, or your district by name.

Grade levels and courses currently taught _____

Grade levels and courses taught last year _____

Years of mathematics teaching experience _____

Mathematics courses taught over the past 3 years _____

Years of teaching experience _____

Highest degree/diploma obtained _____ year completed _____

If your degree in elementary or secondary education please indicated which _____

If you had a major area that you studied in university please name it. _____

If you had a minor area please indicate it._____

Have you taken courses in mathematics education since you graduated with your undergraduate degree? _____

What do you think is one of the most important questions a researcher could ask you about your teaching practices? Please use the back of this sheet to elabcrate.

Appendix E:
Interview Protocol—Principal

- In your view what are some of the school procedures and/or policies that support mathematics teaching and learning in your school?
- In your view what are some of the district based policies that support mathematics teaching and learning in your school?
- Has your school specifically focused on mathematics achievement and if so in what way(s)?
- What is your school's greatest asset? In what way is this the school's greatest asset?

If you were making recommendations to a fellow principal, what would you advise him or her to *start, stop* and *continue* doing to support mathematics achievement?

Appendix F:
Questionnaire Items—Parents

Please send the questionnaire in the envelope provided or fax to the number noted below. Any and all of the comments you make are important to our study. Thank you for your time.

Elaine Simmt
341 – Education South
University of Alberta
T6G 2G5
phone 780–492–0881
fax 780–492–9402

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1. Is your 9th grade child a boy or a girl? _____
2. Does your child find mathematics **easy**, **hard,** or **neither easy nor hard**? _____
3. Does your child do **well**, **satisfactory** or **poorly** at mathematics? _____
4. What do you think makes the biggest difference as to how well your child does in mathematics?

5. What does the teacher do to help your child with mathematics?

6. Can you think of anything else the teacher could do to help your child with mathematics? If yes, give an example or two.

7. What are some of the things you have noticed your child does to learn mathematics?

9. In your opinion, is your child successful in mathematics? Explain how you define success.

10. In your opinion, what is the most significant factor affecting your child's success in mathematics?

11. Are you aware of any school based policies or practices that help students be successful in mathematics? If so, what are they?

12. Are you aware that your son or daughter will be writing a provincial achievement test in mathematics at the end of grade 9?

13. Do you anticipate that your child will be well prepared for the exam? Why or why not?

Much educational research uses data about the family to profile school communities. For our study to fit with existing studies it would be useful if we had the following information. We understand that this is private information and many people do not wish to divulge it. We respect this view. Please be reminded that you are not identifiable from this questionnaire in anyway. **If** you have no objection to providing this information please, circle one response for each item.

Mother's highest level of education

- less than grade 9
- completed grade 9
- some high school
- completed grade 12
- some university, college or technical institute
- completed university, college or technical institute

Father's highest level of education

- less than grade 9
- completed grade 9
- some high school
- completed grade 12
- some university, college or technical institute
- completed university, college or technical institute

For how long have you lived at your current address?

• 3 months • 6 months • 1 year • 2 years • more than 3 years

Which of the following categories describes your annual family income level?

• less than $20 000 • $20 000–$40 000 • $40 000–$60 000 • greater than $60 000

Once again, thank you for taking the time to complete this questionnaire.

Appendix G:
Questionnaire Items— Students

The University of Alberta researcher would like your opinion on mathematics teaching and learning. Your responses to the following questions are important to us. **Although you are under no obligation to complete this questionnaire we hope that you do.** If you feel strongly about not completing the questionnaire, simply hand it back in blank. There will be no consequences for not completing this sheet.

Gender: Female Male

1. Do you enjoy mathematics class? _____
2. Do you find mathematics **easy**, **medium**, or **hard**? _____
3. In your own opinion do you do **well**, **okay**, or **poorly** at mathematics? _____
4. How many nights per week do you have mathematics homework? _____
5. When you have mathematics homework about how long does it take you to complete it? ___
6. What does your teacher do to help you learn mathematics. Make a list.

   _____

7. What is your favorite subject? _____
8. What is your least favorite subject? _____
9. Do you participate in any extra-curricular activities like sports, chess club, choir, student council, etc.? Which ones?

   _____

10. Do you know that you will be writing a provincial mathematics exam at the end of the year? .

    _____

11. How do you feel about writing the provincial mathematics achievement exam at the end of the year?

    _____

12. Do you think you will be well prepared for it? _____
13. What advice do you have for 8th grade mathematics teachers that would help them become better teachers?

    _____

    _____

14. What advice do you have for 8th grade students that would help them become better mathematics students?

    _____